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An Associational Study of
Illinois Sand Prairie

General Science

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AN ASSOCIATIONAL STUDY OF ILLINOIS SAND PRAIRIE

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BY

ARTHUR GIBSON VESTAL

THESIS

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

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ENTITLED "An Associational Study of Illinois Sand-Prairie"

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

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AN ASSOCIATIONAL STUDY OF ILLINOIS SAND-PRAIRIE

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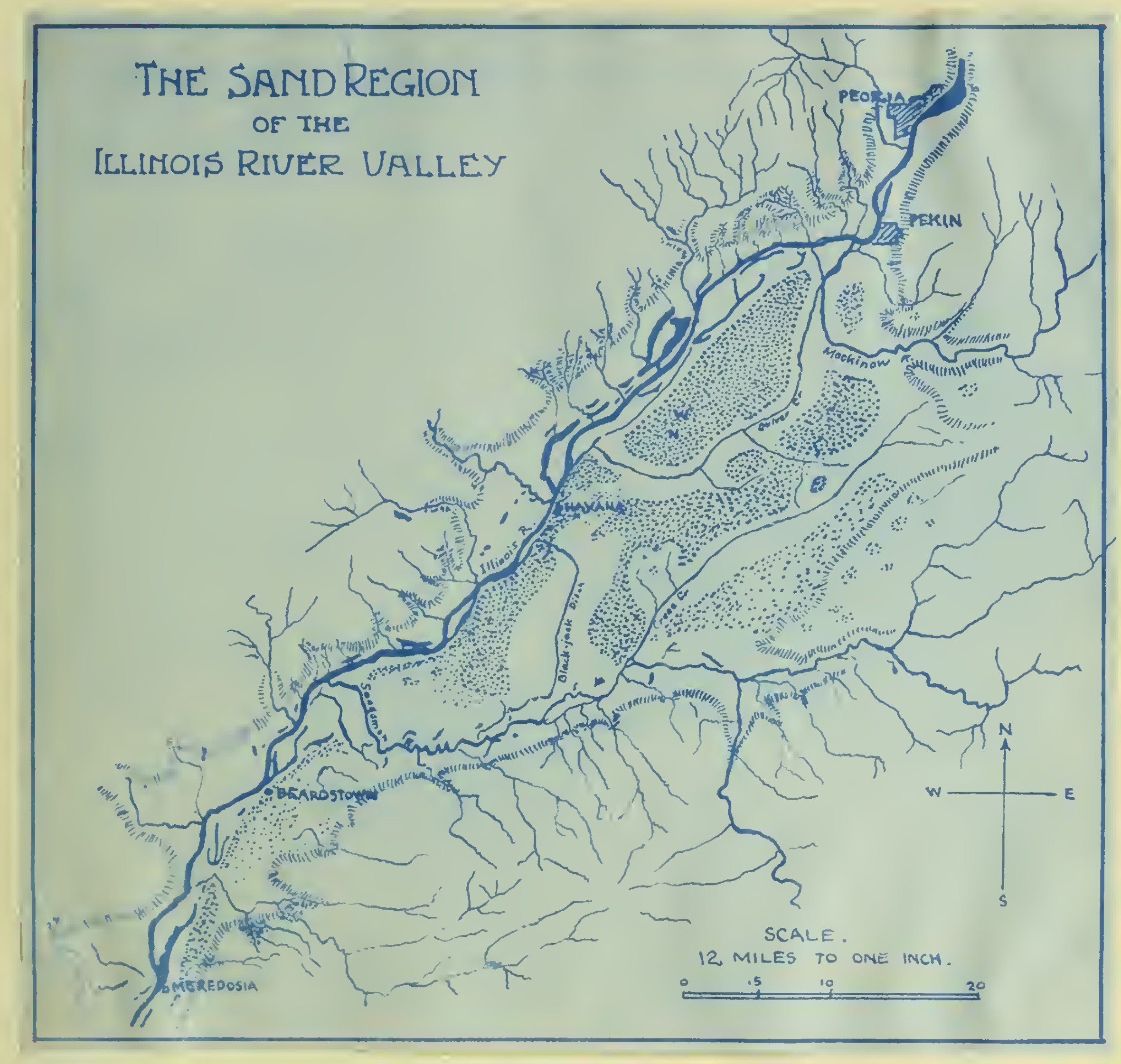

Figure 1.

Map of the region studied, the sandy ridges or islands showing as dotted areas, and the sandy loam flats or ancient stream channels showing as white areas between. The ditches in the middle, when compared with the abundant streams of the uplands, give an idea of surface drainage in sand.

I. INTRODUCTION.

Purpose of the Work.

The study of sand-prairie animals, and of sand-inhabiting animals in general, is by no means a new one. The report of Hart and Gleason (1907) gives an account of the plants and animals in the particular region in which the present studies were made. The description of the animals is primarily faunistic, but both the local and the geographic distribution of species, and the relation of sand and climate to insect coloration, are very ably treated. The writer's attitude is that regional studies should, wherever possible, be approached from the associational standpoint, regarding the association as the unit, and that the animal association cannot usually be treated apart from the plant association. Gleason (1910) has discussed the inland sand plants quite thoroughly, and it is not necessary to consider the plant associations in this account except as a setting for the activities of the animal, and in the more direct relations between animal and plant.

The study of a single association could be made the work of a life-time, and still be far from complete. In such short time as was available for this work, little more than an idea of the composition of the associations, certain of the more obvious interrelations of the various species, and a few notes on the historic and geographic features of the sand-prairie, can be given. The study is therefore presented as an introductory account of the plant and animal associations of Illinois sand-prairie.

Field Studies.

The field studies for the present work were made during the summer session of the University of Illinois at Havana, Mason County,

Illinois, on the Illinois River, from June 20 to July 29, 1910, as part of courses in faunistic zoology, under the direction of Dr. C. C. Adams and Professor Frank Smith, and in plant ecology, under Dr. H. A. Gleason. Nearly all the field work was done at the Devil's Hole, an area of almost pure sand east of Havana. One excursion to the Devil's Neck, a much larger sand area north of Topeka was made, and also a few reconnaissance trips to other points in the sand region. A second visit to Havana was made in the fall (October 3-9), several days being devoted to the sand-prairie at that time, and a third trip in the spring (March 31- April 10, 1911). Emphasis was laid on collection and preservation of specimens, and observation, from the ecological standpoint, of food habits, local distribution, status within the association, and other features, for each species. More attention was given to the insects than to all the other groups of animals; this is quite natural, however, as the insects are the most important and the most conspicuous element in the animal life of the sand-prairie. Indeed, very few faunal studies have treated both vertebrate and invertebrate species, the taxonomic group being the usual unit; the study is not complete until all the animals are considered. The criteria for determining which species are dominant and which secondary, are too complex and indefinite to be laid down on a hard and fast basis. As there is usually no great difficulty in recognizing the relation of the animal to the association, it has been found expedient to delay the analysis and formulation of these criteria. Any species, plant or animal, may be considered dominant in the association, if its removal would seriously affect the nature or identity of that association.

Laboratory Studies

At the beginning of the laboratory work, the method of study resolved itself into three stages:

1. Determination of unidentified species.
2. The study of the individual ecology of each species, by reference to a broad field of zoological writings. This includes a wide range of the activities and life needs of the animal, its assignment to the associations of which it is a part, and a statement of its ecological position in the association.
3. The synthesis, from the complex mass of facts acquired in field and laboratory, of a unified account of each association as a whole, and of the relations of each association to the environment and to the surrounding associations.

In the preparation of many faunal studies, the second stage is treated incidentally or superficially. The information that can be found on habits, local distribution, food, interrelations, etc., in regard to a particular species is scanty in the extreme; especially is this true among the invertebrates, where most of the work has been upon life histories of economic species. The study of the activities and life-needs of all the animals in an association is an enormous task, involving the work of years, and until this is done, no account of an association can be complete. Nevertheless, the work on individual species must be made with the concept of its relation to the association in mind. A very good example of such work is Shelford's paper ('07) on certain tiger beetles in the sandy regions of the Lake Michigan shore. Until all the animals of an association (and the plants as well) are treated in this way, no associational study can give more than a general idea of what the association is like; most of the "how" and "why" must remain unanswered. In the meantime, such broad studies are of value in pointing out specific problems for the further investigation of the how and why, aside from

their intrinsic merit as an introduction to life conditions in a social community of animals and plants.

General Description of Locality

The locality studied is in central Illinois, in Mason County, near the Illinois River. There are two vegetative types in Illinois, prairie and forest. In the northern parts of the state the forests are found in belts along the streams, the large rivers having the broadest forest belts. The sand areas of the Illinois River, though located in a wide forest belt, are characterized chiefly by a prairie vegetation, due to local differences in soil. As will be shown later, the sand prairie differs in many respects from the more luxuriant black-soil prairie of Illinois, and these differences are the combined effects of physical and historical factors.

These sand areas are extensive deposits made by the ancient Illinois River, which was once many times its present size, and by certain of its tributaries. The old Illinois was the outlet of Lake Chicago, of which Lake Michigan is the present day successor, and it subsequently carried away an immense volume of water from the melting Wisconsin ice-sheet, the terminal moraine of which crosses the river in the vicinity of Peoria. Below the moraine the valley suddenly widens, and the entire left bank of the glacial flood-plain is buried beneath many feet of sand and gravel. The surface of these sand deposits consists of several low, broad ridges of almost pure sand, separated by extensive sandy loam flats. The sand plain reaches its maximum width, about 14 miles, in Mason County; toward the south it gradually becomes narrower, reaching its lower end near Meredosia, in Morgan County. It is about 75 miles in length. The total area of

sand deposits is about 179200 acres (Hart and Gleason, 1907: 145).

The physiographic processes which have taken place are two: the action of water in transporting and depositing the sediments, and the subsequent action of wind, in working over the surface materials.

The original vegetation was of three types. The first was the prairie of the level flats, merging into swamps and bogs in the poorly drained areas; these are now drained, and all of the level country is under cultivation. The second was the sand-prairie, which occupied the pure sand of the ridges and dunes. The sand-prairie is of two formations, the prairie or bunch-grass formation, in which vegetative reaction upon the environment results in a dominating tendency toward stabilization of the sand, and the establishment of more mesophytic conditions, and the blow-sand formation, in which the wind is the controlling factor, resulting in a dominating tendency toward continual shifting of the sand, and the establishment of desert conditions. The third type, the forest, is of comparatively recent development in the sand region; it is confined to the pure sand of the ridges, having replaced the sand prairie over a large part of the dune country. The early stage of the forest is very xerophytic, being composed of black-jack oak, black oak, and hickory. The black oak soon becomes the dominant tree, and a more mesophytic forest is developed (this is best seen in the dunes along the river), composed of black oak, hickory, walnut, hackberry, and a few other trees. Most of the forest area is uncleared.

The original fauna has been greatly modified. Most of the prairie swamp animals, such as marsh birds, musk-rats, frogs, and invertebrates,have disappeared, while the animals favored by cultivation have taken their place. In the sand prairie, the small mammals, the

birds, and the insects, have undergone little change. The animals of the forest are modified considerably. The larger mammals and a number of the birds can no longer be found, and their places are filled by other species which have become more numerous.

Acknowledgements

In the preparation of this report I have been greatly aided by other persons. Dr. C. C. Adams, under whose direction the work was done, has been of very great assistance, especially with regard to the literature. I desire particularly to express my appreciation to him. To Professor H. A. Gleason, who has made such extensive study of the sand prairie plants, I am under deep obligations, for guidance in the field and subsequently. I am very greatful to Mr. C. A. Hart, who has helped me in many ways, especially with the insects. I desire to extend my thanks also to Mr. F. C. Gates, who has allowed the use of some of his results, and to Mr. G. C. Mc Fadden, of Havana, who has furnished important information concerning the topography of parts of the Havana region. The determination of many of the insects was made by Mr. Hart; some of the beetles by Mr. J. D. Hood; the ants, Mr. Maurice C. Tanquary; the spiders, Mr. J. H. Emerton and Dr. G. W. Peckham; several parasitic hymenoptera, Mr. A. A. Girault; and a few miscellaneous determinations by Mr. James Zetek; Mr. F. E. Wood has given me important information concerning the mammal species.

II. GENERAL RELATIONS OF THE ILLINOIS SAND REGIONS.

Introductory Statement

The study of the animals of an association consists of two parts, the study of the animals themselves, and that of the environment, the background or setting for the activities of the animals. The environment, as far as the animals are concerned, is also of two parts, the physical environment, and the plant environment. It is with the broad relations of both of these that this section has to deal. Present conditions are so linked with those of the past that it has been found inadvisable to attempt a separation of the descriptive and developmental aspects of the situation.

Animals obey much the same laws of distribution as do plants. Differences between animals and plants in reaction to the physical environment are less real than apparent; it therefore follows that the physical conditions, though often in an indirect manner, determine the ecological type of animals, as well as plants, in a given region. The biotic provinces, or life zones, which are large regions in which a definite set of physical factors are dominant , have been determined with fair accuracy for the plants of North America (Transeau, 1905; Pound and Clements, 1898; Engler, 1902). In these no account has been taken of the animals. Merriam, in his Life and Crop Zones (1898) has confined himself to a single factor - temperature - and his work is one of the latest attempts to map the animal provinces. There are at least three reasons why the provinces should first be determined from the work and view point of botanists, and later from that of zoologists: First, plant ecology has reached a much more advanced stage of development than animal ecology; second, the plant association has a definite physiognomy, which can at once be recog-

nized, and which gives the characteristic appearance to the region, whereas the animal association is not conspicuous, and can be recognized only after extended study; third, the power of locomotion and complexity of behavior of animals results, in a large number of forms, in peculiarities of geographic distribution which tend to make the boundaries less definite than that of the plant province and which also results, for many species, in local boundary differences which tend to confuse. However, it seems safe to assert that there is no fundamental difference between plants and animals in their broad distribution, and we may consider the provinces not only as large areas of certain types of vegetation, but as areas characterized by typical formations of both plants and animals.

General Note on the Prairie Province

The prairie province, in the border of which the present region is located, occupies a large inland area east of the Rocky Mountains; it is characterized by the dry continental type of climate resulting from its geographic position. The moisture from the Pacific Ocean is intercepted by the cold peaks of the rockies, and so the precipitation is slight, increasing, however, toward the east. As the proportion of rainfall is higher in the growing season, a grassland type of vegetation is favored (Schimper, 1903: 175). As the rainfall, the black soil, and the lower altitude favor the eastern part, the most luxuriant grassland is found there. Pound and Clements (1898) have mapped the prairie province and they term the eastern region the prairie-grass region. The more arid belt west of this, the sand-hill region, is characterized by the sand-prairie formation. Its northern limit is near the southwest corner of North Dakota, and from there it

extends as a broad belt southward through central South Dakota, central Nebraska, western Kansas, the eastern border of Colorado, western Oklahoma, and central Texas. The third vegetation region lies west of the sand hill country, along the eastern border of the Rocky Mountains. Itis called the foothill region, and is characterized by open formations of wiry grasses and plants of desert type.

The animals of the prairie province are well adapted to the physical conditions of the prairie and to its vegetation. Craig (1908) has shown that the plant and animal life of the prairie is well adapted to the physical conditions, chief of which are the level character of the open plains, the comparative aridity, and the severity of the winter. The flatness has resulted in a monotonous uniformity of the vegetation, and in the adoption of the wind mode of seed dispersal. In the animals the absence of shelter has given rise to highly developed powers of locomotion, and in some species the adoption of the gregarious habit. The aridity has caused the development of extensive root systems and xerophytic leaf structure in plants, and the underground habit, and ability to live without drinking in certain of the animals. Animals of arid regions also are usually quite pallid in coloration. The winter severity has caused the abandonment of tree structure; the above-ground parts of the plants in winter are dead. The animals hibernate (many of the insects in the egg stage), or migrate southward, as in the case of birds. A few underground forms which store up food remain active during the winter. These three conditions of flatness, aridity, and winter severity determine the entire tone of the prairie biota.

General History of the Sand Prairie Vegetation

Certain plant ecologists believe that after the close of the Illinois glaciation, and again after the retreat of the Wisconsin ice-sheet, the climate of the interior was extremely arid; that the conifers of the ice margin were succeeded directly by prairie plants of intensely xerophytic nature; that there was consequently a great eastern extension of the prairie. The mesophytic prairie-grass of the eastern prairie region had not then reached its present development. There was subsequently an increase of moisturein the eastern states and in the Mississippi valley; this caused, in the east, an advance of the deciduous forest from the southeast, and in the Mississippi valley, the development of the mesophytic prairie formation. West of this region little or no change from the former arid conditions took place; the xerophytic prairie formation of the sand hills therefore was changed little if at all. This partial history of the eastern prairies is supported by a mass of evidence which does not properly belong in this account. This evidence is taken from the distribution of relict colonies of western and northern plants, from the present successional tendencies of our vegetation, and from our knowledge of glacial and climatic history.

If we accept this explanation of vegetational changes in the past, we see at once that after and during the Wisconsin glaciation, the xerophytic grassland, which was then at its maximum development, must have covered most of Illinois south and west of the conifer margin, which never extended far beyond the terminal moraine. But it was at about the same time that the sand deposits of the Illinois River,and similar deposits of the Rock River and the Mississippi, were left uncovered by the diminishing streams. The xerophytic

prairie was therefore the original vegetation of the sand deposits, for it was the only vegetation near enough at hand for invasion. This prairie was continuous in distribution from its present location in the sand hills of the west to central Illinois and much farther east. It has persisted in the west because the arid climate has remained unchanged. It has persisted in the sand deposits of Illinois because physical conditions of the soil, evaporation, and exposure have been such as to keep out invaders not adapted to these conditions. The kinship between the sand-prairie of Illinois and the sand-prairie of the west is shown in the plants and in the animals. Many animals reach the eastern limit of their range in the Illinois sand areas. Others are not continuous in distribution, but occur in the sand areas and also in the west. Others may have been isolated in the Illinois area, and have become distinct geographic varieties. Enough has been said to show that the sand areas of the Illinois River and similar sand deposits in other parts of the state are in reality local eastern extensions of the sand-hills of the middle region of the prairie province, or, what is nearer the true state of affairs, relic colonies of sand-prairie, surrounded by the typical prairie grass and forest formations of Illinois.

In addition to the xerophytic relic colonies in Illinois, other regions characterized by severe physical conditions point toward the former presence of the eastern extension of the arid prairie. The western element gradually fades out toward the east, and is best developed in the most barren habitats. This element is well represented in the flora and fauna of the sandy shores of the Great Lakes. Jennings (1908 and 1909) records from the sand plain of Cedar Point and Presque Isle, two sand spits in Lake Erie, such western plants as

Opuntia rafinesquii, Andropogon spp., Artemesia caudata, and Panicum virgatus and scribnerianum. A larger number of western plants, and a very considerable number of western animals, are found at the lower end of Lake Michigan. Several sand regions occur in Indiana, the most extensive being the Kankakee River valley sand area. The principal sand areas in Illinois, aside from the Havana and Lake Michigan regions, are the Kankakee area, along the Kankakee and Iroquous rivers in eastern Illinois; the Amboy area, on the Green river, in Lee County, in which very little sand-prairie is left; the Dixon area, in Lee County; the Winnebago County area, now mostly forested; and the Oquawka area and the Hanover area along the Mississippi, in which very extensive tracts of sand-prairie are found.

Western relics are found on the xerophytic sandstone outcrops in La Salle County along the Illinois river, and in Ogle County along the Rock river. The outcrop of Sioux quartzite in northern Iowa furnishes xerophytic conditions of plant growth, and in a report on its flora, Shimek (1897) records Opuntia, Buchloe, Chrysopsis, Bouteloua, Sporobolus, and other plants of western derivation. All these colonies of plants and animals, a large number of which are derived from the sand-prairie, indicate the former presence of arid conditions.

III. THE PHYSICAL ENVIRONMENT

The Topography of the Sand Region

Over most of the sand region the topography indicates that other agencies than wind have been at work; the ridges extend in a direction roughly parallel with the river, often being more than two miles across. They rise gradually from the plain; the highest points, near the middle, are often as much as fifty or sixty feet above the general level. The surface of the ridges has been modified by the wind into dunes and blowouts, and , aside from the general ridge-like form, presents the appearance of a typical dune complex. One line of sandhills (fig. 2, p.17) starting from the marginal sand ridge of the river, a mile or two south of Havana, and extending in a northeasterly direction for four or five miles, presents the only evidence of pure wind origin. The long axes of these hills lies in the same direction as the whole range; they are usually about forty feet high and a quarter-mile long. The sand composing them is quite pure, and the bunch-grass with which they are covered has not reached a very advanced stage, indicating that they are of comparatively recent origin. The Devil's Hole is one very sandy part of these dunes. Some of the fields in this region have been plowed up; the blowing immediately became so serious that agriculture had to be abandoned, and now what part of the sand is not still blowing is reverting to bunch-grass. The bunch-grass is usually pastured.

The large island between the Illinois and the old channel of the Mackinaw (now occupied by Quiver Creek) presents the surface configuration of a stabilized dune complex. On the former island, three miles north of Topeka, is the blow-sand region known as the Devil's

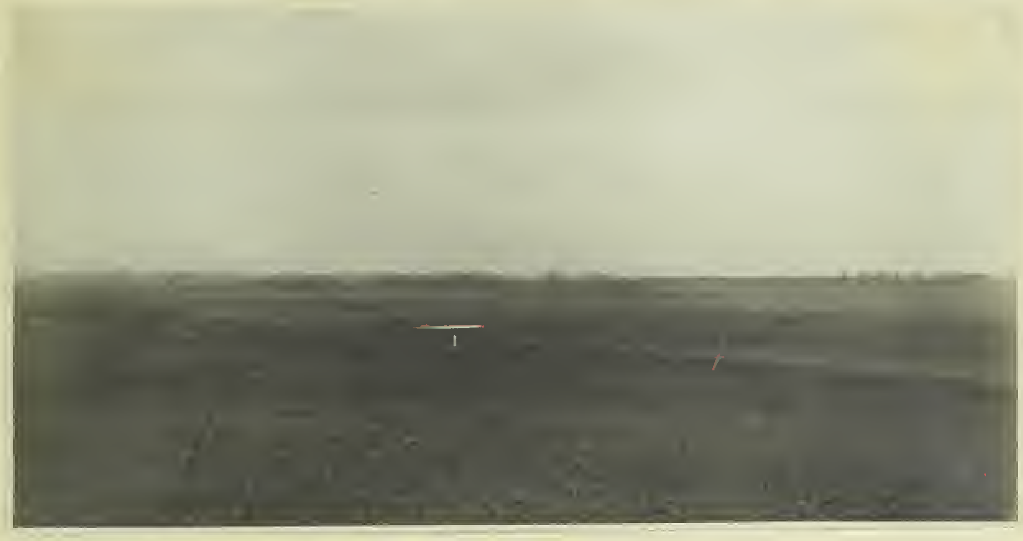

Figure 2

A sandy loam flat southeast of Havana. The line of dunes on the horizon is continued to the northeast. The Devil's Hole is situated in this ridge. The water tower of Havana is seen in the center.

Neck. This is almost entirely under the control of the wind, and has an area of about 80 acres (fig. 3 , p. 19). A triangulation station of the Illinois river survey of 1905 is situated on one of the highest dunes on the island, about a mile north and east of the Devil's Neck. The top of this dune is seventy feet higher than the trough of a depression not far away, and from the summit an uninterrupted view for miles may be had (fig. 4 , p. 20; fig. 3, p. 19).

The drainage line of Crane Creek, extending from the Mackinaw valley through the re-entrant northeast corner of Mason County in a southwest direction to the Sangamon river, marks another of the great channels of the ancient stream. Figure 15(p.172) shows the present aspect of the Crane Creek flat, from a dune southwest of Poplar City. The Black-jack Ditch occupies another broad flat, extending northward from the Sangamon bottomland nearly to Havana. Its northern end is drained by White Oak Run, which flows west into Matanzas Lake. The flats of Crane Creek Ditch and the Black-jack Ditch are covered with the sandy loam soil, and until they were used for agriculture, were very swampy, certain spots having been under water almost the year round. The subsoil is usually a very porous gravel, and it is thought by some that a hard-pan layer must have been formed near the surface to prevent the water from sinking in. The flats are now drained by dredged ditches, and the area is devoted to agriculture. The map shows the relation of the level areas and the islands or sand areas, and the general appearance suggests the manner in which the floods from the melting glacier spread the alluvial material over the broadened valley. The Mackinaw river has had a share in the work of deposition; its drainage channel may at one time have proceeded by way of Crane Creek into the Sangamon.

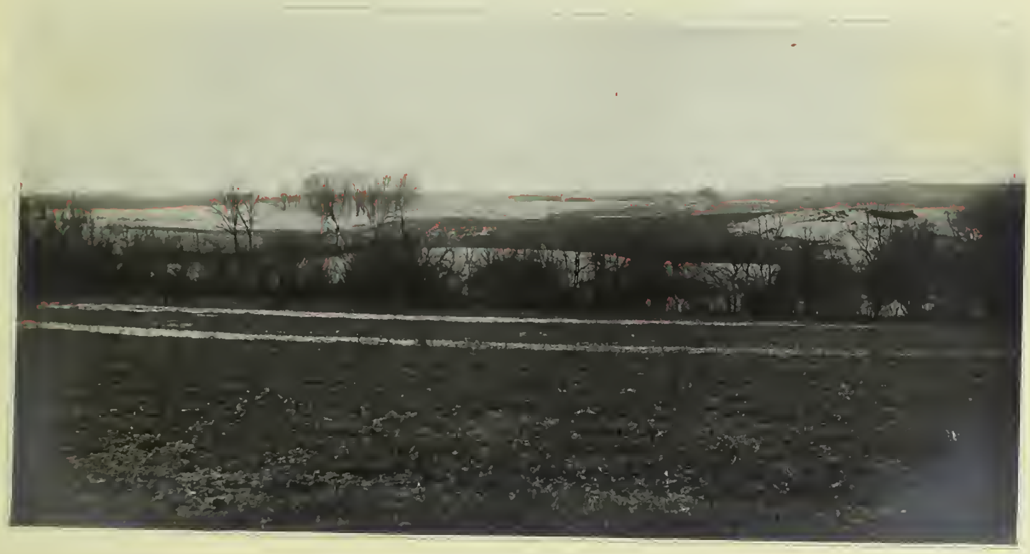

Figure 3.

A view of the Devil' Neck, from a dune to the east.

In this and other photographs, the light colored areas are patches of bare sand, which often appears like snow in the picture.

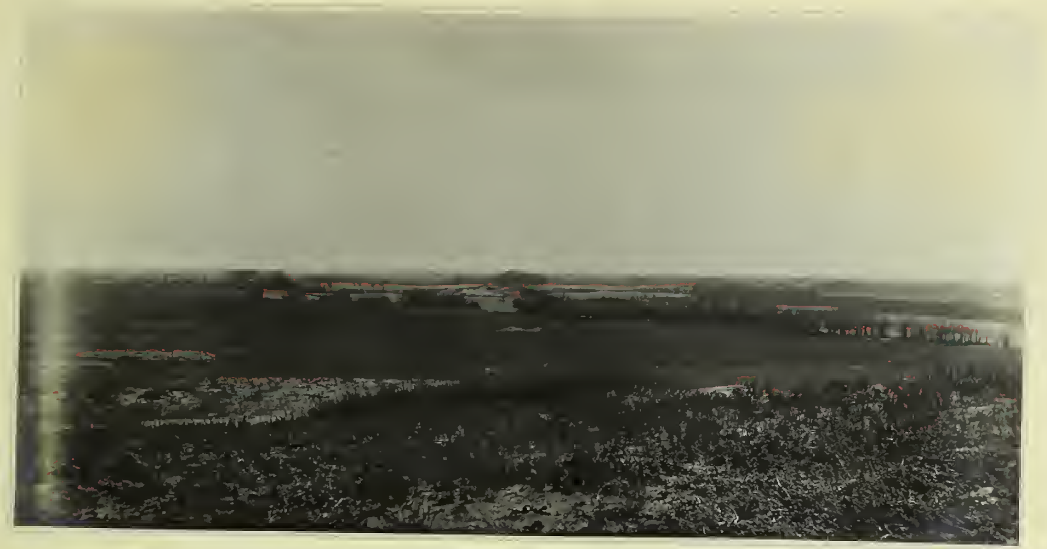

Figure 4.

View from top of"Watch Tower Hill", showing the height above the surrounding country, and the Devil's Neck.

The island between Crane Creek on one side, and Quiver Creek and the Black-jack Ditch on the other, is not so clearly defined as the one on the other side of Quiver Creek, nor has its northern end been studied. I have been through most of its southern half, and the boundaries given on the map for it are fairly accurate. The other large island, lying between Black-jack Ditch and the river, is very sandy, especially near Saidora. The other parts of the same region have not been studied.

The Physical History of the Sand Deposits

The physiography of the sand region is discussed in the Soil Survey for Tazewell County (Bonsteel, 1903), with a description of the soil types, and a map showing their distribution. Chamberlin and Salisbury (1885: 261, 262) describe the method of deposition of glacial outwash, especially in the Mississippi river valley. Important information is also found in the Illinois Glacial Lobe (Leverett, 1899) and in the reports of Hart and Gleason (1907), and of Gleason (1910).

In the later stages of the Wisconsin glacial period sand had been deposited as flood-plain and river terrace formations, carved out to an immense size. The alluvium was laid down mostly on the east bank of the river; the coarser materials having been dropped the soonest. Just below the Peoria moraine a number of bowlders occur, at Pekin the deposits are rather coarse gravel, in the Havana region they are fine sand with larger particles interspersed, and at Meredosia they consist entirely of very fine-grained sand. Still farther down, the sand disappears altogether, and is replaced by silt. Underlying the surface materials, throughout the extent of the region, are coarser sands and gravels, in cross-bedded and stratified layers.

Two hypotheses have been formed to account for the differentiation of the level areas of sandy loam and the ridges of fine, almost pure, sand. Bonsteel (1903: 473) says that the subsidence of the river left a flat sand-plain, mixed with more or less mud or silt at the surface; and that the ridges have been blown up successively from the sand exposure of the river bluff, and have been migrating steadily across the plain since, impelled by the prevailing westerly winds. It is improbable that such a broad plain (fifteen to twenty miles at the widest point) should have been deposited in this way without a very radical and sudden decrease in the volume of water. Moreover, there is no indication that the ridges are of such great difference in age; no evidence of such difference is apparent; and it would scarcely seem that, with the continual blowing of the dunes, level areas as great as four miles wide and fifteen miles long could be left as loamy flats with hardly a trace of elevations of pure sand upon them. It is undoubtedly true that the marginal sand ridge has blown up from the river, and that a certain amount of eastward migration of large dunes has taken place, but if the sand had all blown up from the river one would expect to find one huge dune complex, instead of alternating sand-ridges and loamy flats.

A second explanation is found in the report of Hart and Gleason (1907: 145), giving the origin of the ridges as sand-bars in the overloaded stream. This is quite probably the case. The gradual decrease in volume of the river, which resulted from the wasting and gradual recession of the melting ice, would tend to overload the stream to a still greater extent, and the normal result would be divided stream channels, broad and shallow, separated from one another by broad sand-bars, similar to the braided stream effect of the river Platte, but on

a much larger scale. The sand bar hypothesis, however, does not account for the origin of the broad level areas. I am of the opinion that these may well be of a further and sudden decrease in volume of the river, which would leave dry all of the channels but the deepest one, which occupied the most direct route down the valley, near the west bluff. Geologists tell us that a considerable flow of water came down from Lake Michigan, or Lake Chicago, as the ancient lake is called, through the Illinois river, which at that stage is known as the Chicago Outlet. This outlet was established after the glaciers had receded to some extent, and was still open at the time the sand-bars, or sand islands, were formed. Although the stream was much smaller than it had been when the sand-plain was scoured down, it was still many times its present volume. The closing of the lake outlet, caused probably by the opening of a lower one at the head of Lake Chicago, would thus result in a sudden and considerable decrease in the volume of the Illinois river - just such a decrease as would be necessary to leave the broad shallow stream channels dry. The small volume of water which remained would thus be confined to the deepest channel, which occupied a position very similar to that of the present river-bed. The present river and flood-plain are shown in figure 5 (p.24).

The above account of the physiographic changes is presented merely as a possible outline of the actual occurrences. There is reason to believe that the change may have been more complex - the different channels may not have all been drained at the same time, or the sandy loam flats may represent flood-plain deposits of the main river channel at different times. Since the channels have been drained, the sand dunes have shifted about to quite an extent, and the

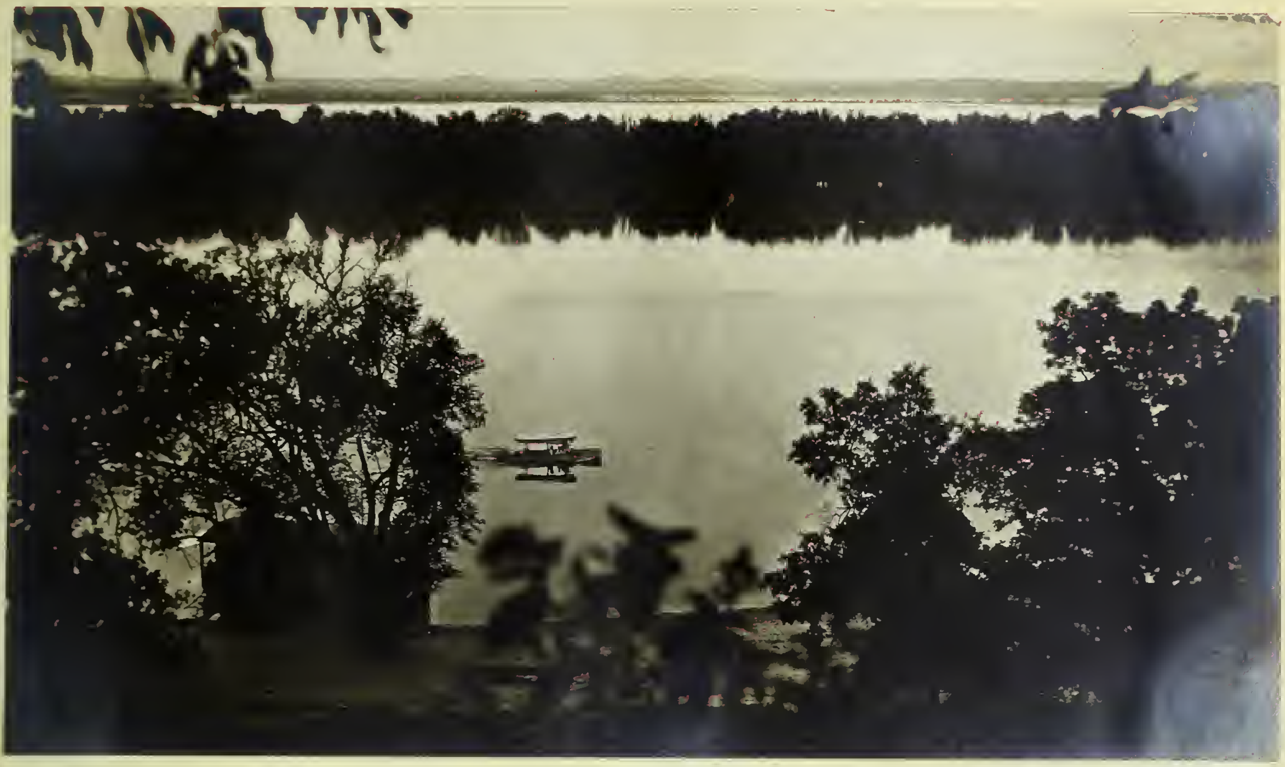

Figure 5.

Lakes of the Illinois River flood-plain. Quiver Lake and the Illinois River, which are here confluent, occupy a broad space to the belt of willows. Beyond is Flagg Lake: beyond that is Thomson's Lake. At the horizon iz seen the east bluff of the river. In high water one can row across the whole system of lakes, over the flooded bottoms which separate them.

recent bed of the river has been cut out of the terrace which at Havana is thirty to fifty feet above the river.

Physical Factors of the Environment

The physical factors of a land environment have been classified by Schimper (1903: 159-161) into two groups - climatic factors which operate over very broad areas, and edaphic factors, which affect local modifications of the plant life (and the animal life as well) in any such broad region. The ecological type of the vegetation (whether forest, grassland, or desert) is primarily dependent upon the climatic factors, temperature, rainfall, and humidity of the air. The ecological type of the animal life is also dependent upon these factors directly, and indirectly through adaptation to the ecological type of vegetation; we may thus speak of forest or grassland animals just as we speak of forest or grassland plants. The climate of Illinois favors the growth of the deciduous forest (Gleason, 1910: 117; Schimper, 1903: 162-175; Transeau, 1905). The sand-prairie has been enabled to persist only through the presence of local conditions of aridity.

The edaphic factors to be considered in any regional study are heat, light, water and humidity, wind, soil, and topography. These edaphic factors make up what might be called an environmental complex; they are so closely interrelated that they cannot readily be analyzed and classified. It might be well to include them all under the term "physiography", for local environmental conditions are primarily matters of physiography. The most important physiographical feature of the region studied is the soil. Sand has peculiar physical and chemical properties, which greatly influence the other edaphic factors. These factors may now be discussed in detail.

Temperature variations in sand from day to night and from the surface to the subsoil are great. When the association is open, as it usually is, the insolation is heightened by reflection; heat and light are thus both intense (Gleason, 1910: 34).

The moisture relations of sandy soils are peculiar. Coarse-grained soils hold relatively small amounts of water; on the other hand, more of this water is available to plants than in fine-grained soils. Coarse loose soils dry very readily at the surface; there is a compensating tendency here, too, as the dry surface layer forms a mulch which retards further evaporation, so that there is always considerable moisture in the sand a few inches below the surface. The amount of evaporation therefore depends more upon the degree of openness of the association than upon the kind of soil. The amount of evaporation depends upon (T. Russell, 1888) the temperature of the evaporating surface, the relative humidity of the air, and the velocity of the wind. Quantitative evaporation experiments in plant associations have been carried on by means of porous cup vaporimeters at the Desert Laboratory, at Tucson, Arizona, by Livingston (1906) and on Long Island by Transeau (1908). Transeau's work shows that in a given locality the evaporation is greatest in open associations. Mr. F. C. Gates, during the summer of 1910, carried on a number of evaporation tests in the different associations in the Havana locality and has kindly permitted the use of his results. The figures in the table below express relative amounts of evaporation. These readings extended over most of the month of July.

Relative Evaporation in Associations near Havana, July, 1910.

Standard evaporimeter, in sandy flat near marginal dune	1.000
River beach, on dry sand	.933
Bottom land forest across the river (*Salix-Acer*)	.560
Bottom land forest composed purely of *Salix*	.443
Bunch-grass, *Leptoloma* consocies	1.178
Bunch-grass, *Eragrostis* consocies	1.040
Blowout, large bare area	1.270
Black-oak forest	.660
Black-oak forest, beginning of mesophytic stage	.550
Mixed forest, near the center	.293
Mixed forest, near the margin	.356

The standard evaporimeter represents nearly the proportion of evaporation in the sandy loam fields. The surface was sprinkled with a little loose sand which had drifted from the steep lee slope of the near-by river dune. The bottomland stations were flooded during the first part of the experiment; this probably did not materially affect the reading. The sand-prairie associations tested were at the Devil's Hole, and the forest stations were in the woodland strip just east of there. The mixed forest at this point had not nearly reached the advanced stage of the mixed forest of the marginal dune. An evaporimeter placed there would doubtless show a very low coefficient. The coefficients in the above table vary directly as the openness of the association. The evaporation in one of Transeau's most open associations, a gravel slide, was a little more than three times the evaporation in the mesophytic forest of Long Island. The evaporation in the Havana blowout is more than four times that of the mesophytic forest at Havana. The blowout is probably more exposed than the Long Island gravel slide. The moisture relations in the Illinois sand areas may be summarized in the statement that the water supply is ample, and that the evaporation depends not so much upon the soil as upon the plant covering.

The dry surface layer of the sand, in addition to its property of

retarding evaporation, has another and more direct effect upon plant and animal life. This layer is practically sterile; seeds cannot germinate in it, and must be buried. Certain plant seeds (as those of Cenchrus) are armed with hooks or spines, perhaps to hold their position in the sand and keep from blowing about on the surface. These may later be buried by blowing sand and germinate. Other seeds (Aristida tuberculosa and Stipa spartea) are able to bury themselves, and round seeds have some chance of settling beneath the surface (Gleason, 1910; 93). Roots of plants do not branch out until they get below the layer of dry sand. Burrowing animals usually stay beneath the surface layer, which in other soils usually is abundant with life. To prevent their burrows from caving in, insects and spiders usually line the mouths with silk.

Wind in the sand regions is one of the most inportant factors. The looseness of the soil enables the wind to pick up the sand and carry or drift it about. The carrying power of the wind for fine particles increases over that for coarse particles in a very high ratio, and is thus selective in its action, sorting the sands according to the size of particles. The blowing of the sand results in continual change of the surface topography, sand being removed from certain places and being deposited in others. Plants which live under these conditions must therefore be able to resist burying or undermining.

The soil as has been stated is the principal one of the factors which give an individuality to sand environments. Most of the physical properties of sand are discussed in connection with the other edaphic factors. The chemical properties are also important. Organic matter and mineral substances in solution occur in sand in very small

proportions, consequently the soil is very deficient in plant food. The soil is usually slightly acid, and this tends to keep it poor in nitrogen, as the nitrifying bacteria do not thrive in acid soils. The low content of lime keeps out animals with calcareous shells, such as land snails.

The topography of sand regions is of a characteristic type, due to the predominance of wind agency. Rain sinks readily into the porous soil, and surface drainage is very poorly developed. No streams at all are found on the sandy islands, and those of the loamy flats are merely sluggish ditches, usually dredged. The map on page 3 gives one an idea of comparative development of streams in sand and in clay. The ground water issues from the sand all along the river bank. The rapid drainage takes away the soluble content of the soil almost as soon as it is formed and this continual leaching keeps the soil poor, greatly retarding the development of the vegetation.

On the whole, physical conditions are inclined to be severe in sand-prairie, favoring more or less open associations.

IV. THE PLANT ENVIRONMENT

Local History of the Vegetation

In the general account of the sand region, it was shown that the uplands on both sides of the river were covered by a growth of xerophytic prairie, and that this prairie was the first vegetation to invade the sand bars and islands of the overloaded river. It is probable that a subsequent decrease in the volume of water left many of the shallow stream valleys as broad poorly drained flats; these were soon invaded by the swamp and bog associations, now found in the north, which must have been abundant along the bottoms and bayous of the river. Certain relic colonies of the bog associations still persist at the head of Matanzas Lake and along the north shore of Quiver Lake. They are characterized by northern plants, as Peltandra, the fern Onoclea, the lizard's tail, Saururus, and others. Northern insects such as Corymbites pyrahos have also been taken. The old bottom of the Mackinaw river is filled with peat, and the broad level areas were entirely grown over with swamp vegetation. From that time to the present, changes in the vegetation in the level areas and in the ridges have represented entirely distinct orders of succession.

The arid climate which accompanied the retreat of the glaciers was at about this time gradually changed, the rainfall was materially increased, and the temperature became probably somewhat cooler. It is an unpublished opinion of Professor Gleason that the eastern, or prairie-grass formation, had not developed before the change in climate, and that this gradual change favored the evolution of a mesophytic type of prairie, over the whole eastern extent of the province. The uplands on both sides of the river, surrounding the sand-plain, were soon covered with this black-soil prairie, to the exclusion of the

older xerophytic type, which was, however, preserved with little or no change, on the sand ridges. At the same time, or a little later, hydrophytic members of the same swamp-prairie association appeared on the sandy loam flat and began to compete with the northern bog type, which gradually gave way to its western rival, except in a few localities unfavorable to the invaders.

Another far reaching effect of the increase of rainfall and humidity was the spread westward and northward of the deciduous forest, which during the arid period was probably developed only a short distance north of the Ohio River. The northern migration in the eastern states (Adams, 1905) was aided materially by a northward moving wave of temperature increase, which followed the retreat of the ice-sheet. This extension of the forest to the north and west is evidently still in progress, though it is obscured by the clearing of land for agriculture. In the Havana region the forest probably first came in from the southwest by means of the Mississippi and Illinois rivers. The bottomland association was the first forest type in the upstream migration, willow and poplar being the pioneer species; this forest type came to occupy a narrow strip along the margin of the sand-plain, and probably the whole new flood-plain in the western edge of the valley. The semi-xerophytic and mesophytic oak forests followed the bottomland type up the Illinois, and spread laterally from the river, replacing to a large extent the black-soil prairie of the uplands. The forest could not at first invade the sand region; the level areas were too wet and were already covered with swamp-prairie; the sand ridges in their open condition were distinctly unfavorable to forest growth. In time, however, the xerophytic black-jack and black oak were able to establish themselves on the sand ridges. The succession from

bunch-grass to forest is probably still going on very rapidly in the Illinois river valley region; this fact and the records of early explorers lead us to think that the forest invasion is very recent (see Gleason, 1910:120). The manner in which the succession from bunch-grass to forest takes place is not known. Once the forest is well established, the vegetation assumes complete control of the environment, and save for the factor of leaching, the peculiar unfavorable qualities of sand are no longer operative. The climatic factors of temperature and rainfall, since the time of the amelioration of the climate, have made the forest the dominant plant formation of the region. The forest has developed, in certain places on the sand, to a transitional mesophytic stage, which Gleason has called the mixed forest. This is best developed along the marginal ridge, probably indicating that the forest was established along the river first (fig.6 , p.33). The forest on both sides of the black-jack flat has over most of its area not developed beyond the black-jack stage. The forest near Manito and Forest City are largely black oak. The climax association toward which the forest development is tending is not known, but I think from comparison with the forested dunes at the lower end of Lake Michigan, which have reached the climax beech-maple-red oak stage that the mixed forest will ultimately develop into the red oak-hard maple forest. The red oak is present now in small numbers; the herbaceous plants forming the ground cover are more or less indicative of advancing mesophytism.

The development of the sand-prairie in its gradually firmer control of the environment may be measured by the amount of humus in the soil, and by the degree of openness of the vegetation. There are all gradations, from the bare, almost pure,. sand of the blowout

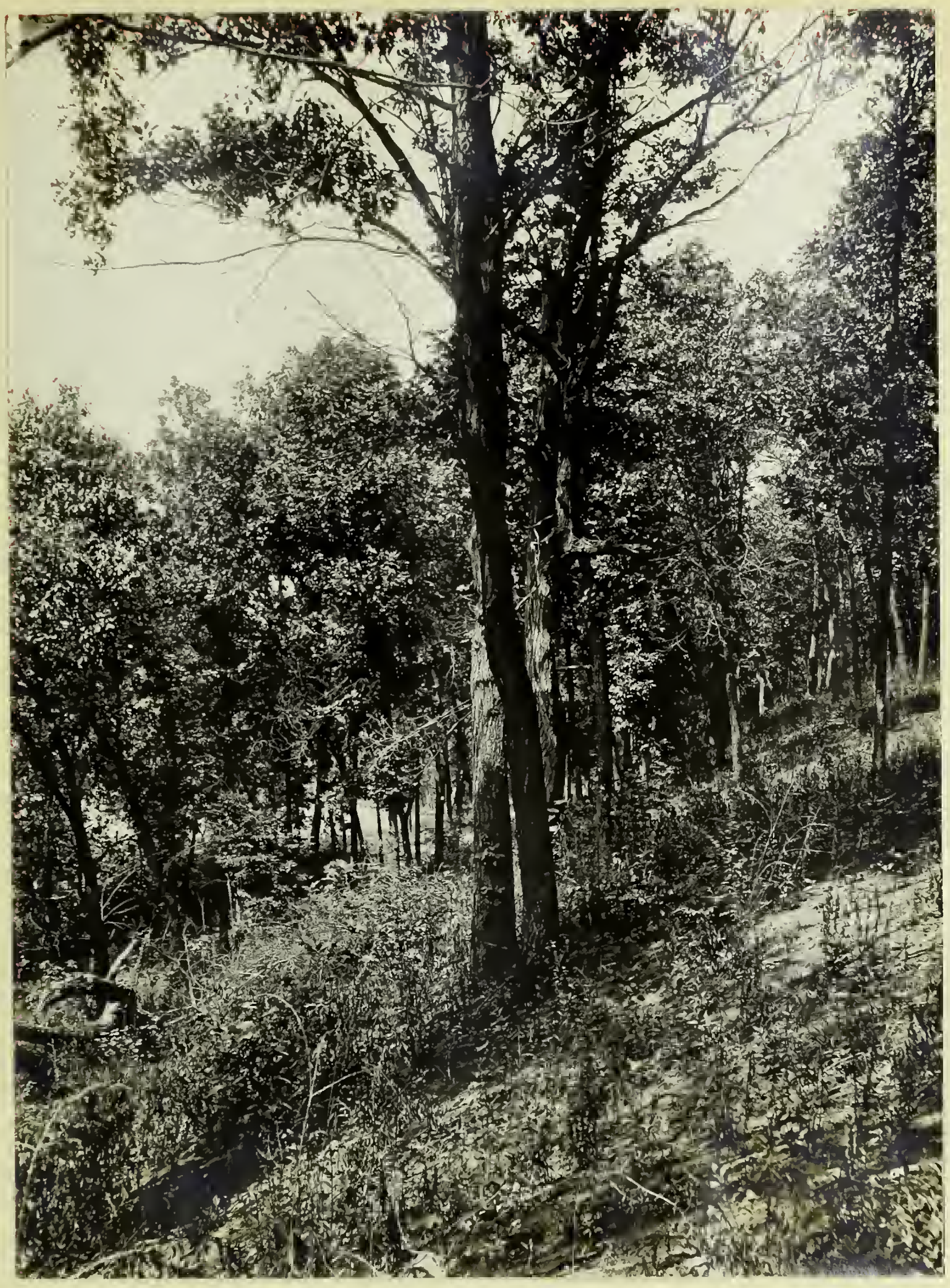

Figure 6.

Mixed forest in the Quiver Lake marginal dune, north of Havana.

associations to the dense sod-like structure of the climax stage, with its dark brown soil which approaches a sandy loam. When the bunch-grass approaches its maximum development, the soil has become dark with humus, the dense tufts of grass have crowded together, eliminating almost entirely the spaces of bare sand between them, and the cactus has been almost entirely superceded by grasses. The earlier stages of this successional series take a very long time to complete, and there is constantly the danger of accident resulting in wind control. Over many parts of the sand region the bunch-grass has passed the danger of blowing, and such areas are usually under cultivation at the present time. Much of the country in the neighborhood of the Devil's Neck, among other places, is cultivated, though here and there spots of sand are found which are still subject to wind action (fig. 3 , p.19). There are a great many hedges in the sand region; they stop the drifting of the sand temporarily, but it soon piles up against the barrier, sometimes even reaching the height of the hedge, burying it and the field beyond. In any event, it does little good to encourage dune formation, as the sand is much more easily stabilized when level. Agricultural methods should rather favor a gradual modification of the soil by plowing in the straw (only the head of the grain being removed in harvesting) and by top dressing with clay and straw wherever the danger of blowing is greatest. These methods are merely an amplification and a hastening of the natural process of stabilization.

It is rather a matter of regret that scientists could not have studied the sand region before the drainage of the swampy flats, the plowing of the denser sand-prairie, and the pasturing of the more open bunch-grass, took place. Yet large areas in the sand-plain

probably have lost little of their natural aspect, and the former condition of the cultivated fields can usually be reconstructed in terms of processes which have been, and are, responsible for changes in the environment and in the associations.

The Vegetation as an Animal Environment

It is a well-known truth that animal life is absolutely dependent upon plant life, which converts inorganic matter into vegetable tissue. The plants may thus be considered the dominant organisms in an association. It has been said that the plants are parasitic upon the earth, that plant-eating animals are parasitic upon the plants, and that predaceous animals are parasitic upon the plant-eaters. The plant-eaters and even the plants are thus just as truly predatory as the most blood-thirsty carnivore. Each organism is wholly self-seeking.

Plants have, roughly speaking, a simple environment. They depend primarily upon a single set of conditions, the physical factors. Animals have a dual environment. They must adapt themselves to the physical conditions, and to the vegetation as well. We find many animals which are so specialized in their adaptation to plant life that the direct relations to the physical environment are not apparent. An insect which makes galls in leaves would serve to illustrate. Other animals depend less directly upon the vegetation, and more upon the physical conditions. A tiger beetle is such an animal, its food being any kind of insect: it depends upon physical conditions of the soil for its oviposition and for the larval burrow - yet the plants so modify the physical conditions of soil and humus that a plant succession is followed by a tiger beetle succession (Shelford, 1907)

and the beetle, though not directly adapted to the plants, nevertheless is part of the same association, which is dominated by the plants. The relation of any animal in an association to the plants which dominate it can be shown in a similar way, though this relation has been worked out for only a very few of our species.

Since each animal of the association is thusdependent upon the vegetation, it would seem that the entire assemblage of animals is dominated by the vegetation. This cannot be determined with certainty until a large number of associational studies are made. It gives us, however, a very valuable working hypothesis, and makes the botanical studies directly applicable in the associational aspect of animal ecology. We may on this basis assume that the history of the animals in the Illinois sand-prairie has in large part paralleled the vegetational history. We may also assume that plant successions are accompanied by corresponding animal successions; and that a definite assemblage of plants is always accompanied by a certain definite assemblage of animals, which together make up a biotic association; and that this identical assemblage is never found accompanying a different assemblage of plants. This does not mean that the association is to be interpreted as an assemblage of exactly so many plants and exactly so many animals to correspond, in exactly such and such a proportion of abundance or dominance, or that the same association cannot be represented in two localities if a few species are more abundant in one, or if a few other species be added or absent. No rigid interpretations can be made, nor are they needed. The association is something that is very real and easily recognized. Given a set of physical conditions in a region, one can predict the ecological type of its potential plant covering; given a definite type of

plant assemblage, one can predict the ecological type of the corresponding animal assemblage.

Most of the studies which have been made of land associations have treated only the plants. This is natural because the plants are much less dependent upon the animals than the animals upon the plants, and the dominating influences must be treated first. There is thus no discredit upon zoological workers; they must be careful, however, not to fall into the error of neglecting the plant studies; no understanding of the association is possible without the knowledge of the dominant feature, the plant assemblage. The zoologist must therefore avail himself of the large amount of work that has been done by the botanist. He should build upon the botanist's structure rather than attempt an independent foundation for his own.

The associations have already been named by the botanist, usually with reference to the dominant feature, be it physical or vegetational. By the"bunch-grass association" or the "black oak association", whenever they occur in the following pages, is not meant the plants alone, as in botanical writings, but the entire association of plants and animals.

V. THE ASSOCIATIONS OF THE SAND PRAIRIE

The classification of the associations, and the description of the plants is based on the work of Gleason (1910), with the exception of the discussion of the climax sand-prairie association. These associations are quite distinct from one another from the botanical point of view, and a close study of the animals shows a definite demarcation of the animals of the different associations as well. The ability of the animals to move about, however, makes the conditions for study somewhat more complex. The sand-prairie is composed of two formations, the prairie formation and the blowout formation.

The Prairie Formation.

The important ecological feature of the prairie formation is the control of the physical environment by the vegetation. Though the formation is open, it is usually quite stable, and the processes at work tend toward the binding of the sand, the gradual enrichment of the soil through the accumulation of humus and the ultimate establishment of a closed formation. The dominant plants are grasses; the dominant animals are grass-eaters, such as locusts and other phytophagous insects, rodents, and other animals. The associations in the prairie formation are three: the bunch-grass association, the _Panicum pseudopubescens_ association, and a closed association which represents the culmination of the sand-prairie, which may tentatively be called the climax sand-prairie association.

The Bunch-grass Association.

The soil of the bunch-grass association is sand, mixed with a little humus. The association is open, usually about twenty or

thirty per cent. of the surface being exposed. The patches of bare sand are dry at the surface, but are not greatly subject to wind action. The topography is usually undulating, the elevations having the aspect of stabilized dunes, which, in fact, they almost invariably are (fig.7 , p.40; fig. 8 ,p.41).

The dominant plants of this association are the bunch-grasses, which form dense tufts or bunches, in which the dead leaves of the year before remain. The bunches are separated by patches of bare sand. The general appearance of the association depends upon that of the species of bunch-grass which happen to be abundant. The important bunch-grass species are Koeleria cristata (Linn.) forming large regular tufts, higher in the center; Leptoloma cognatum (Schultes) Chase, with large, compact, flat-topped tufts; Stipa spartea Trin., tall, loose, few-leaved; Panicum pseudopubescens Nash, with short, broad leaves, forming very flat bunches, often eighteen inches in diameter; Bouteloua hirsuta Lag., very depressed, grayish bunches, which are often subordinated by othergrasses; one, possibly two, other species of Bouteloua; Cyperus schweinitzii Torr., a sedge forming sparse, open bunches; Andropogon scoparius Michx., and Andropogon furcatus Muhl., forming very large bunches.

The bunch-grasses permit the growth of the secondary plants only in the small areas of bare sand between the bunches. These secondary plants form three ecological groups, which may be called perennials, mats, and interstitials.

The perennials are usually deep-rooted, most of them growing in buncheslike those of the grasses. These are usually able to withstand the encroachment of the grasses, but cannot displace them. The typical perennials are Aster linariifolius Linn., Lithospermum gmelini

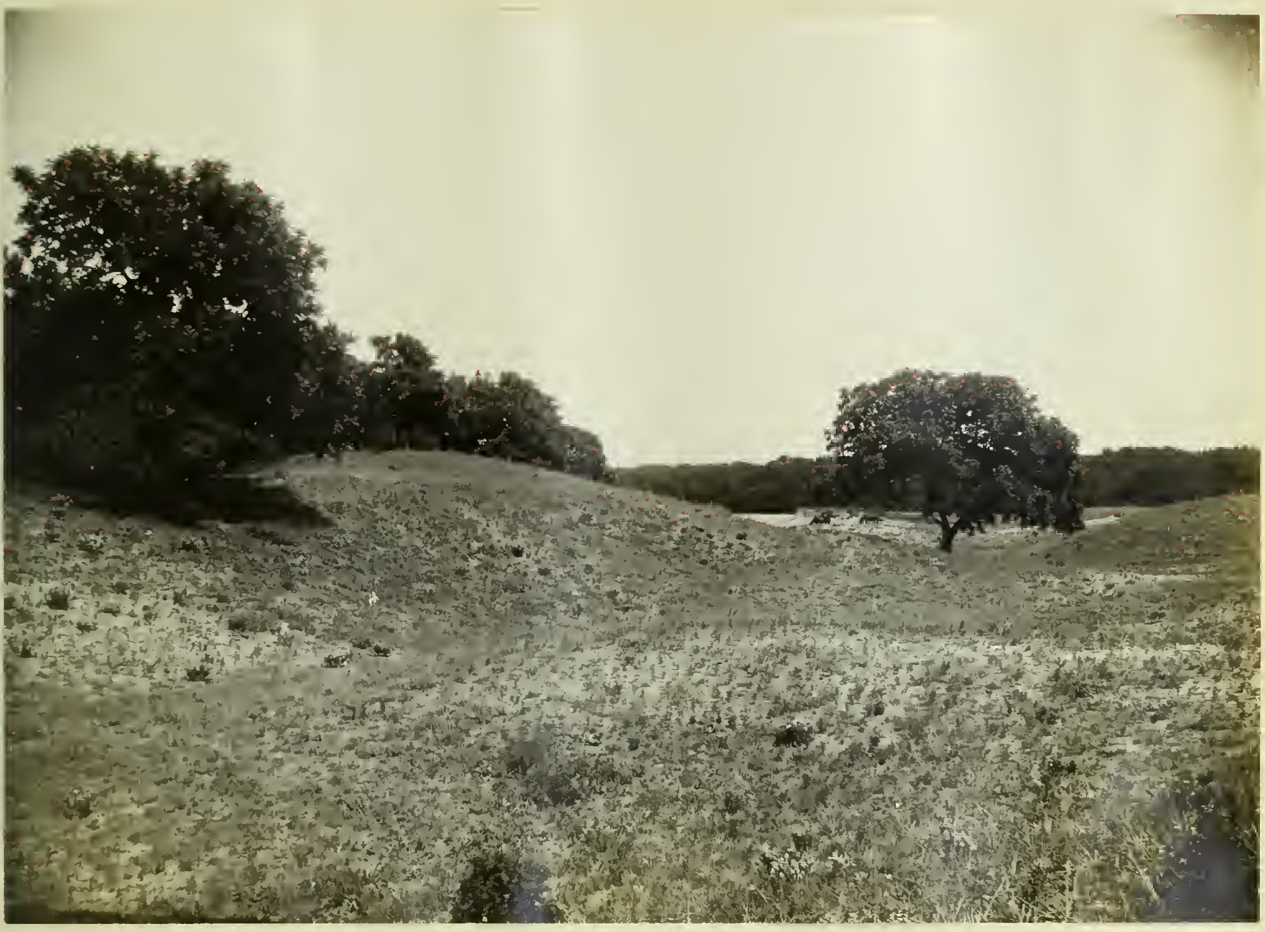

Figure 7.

Pastured bunch-grass at the Devil's Hole. An area of bare sand is seen in the background; to the right of this area is indicated the former level of a dune which has been blown away in large part.

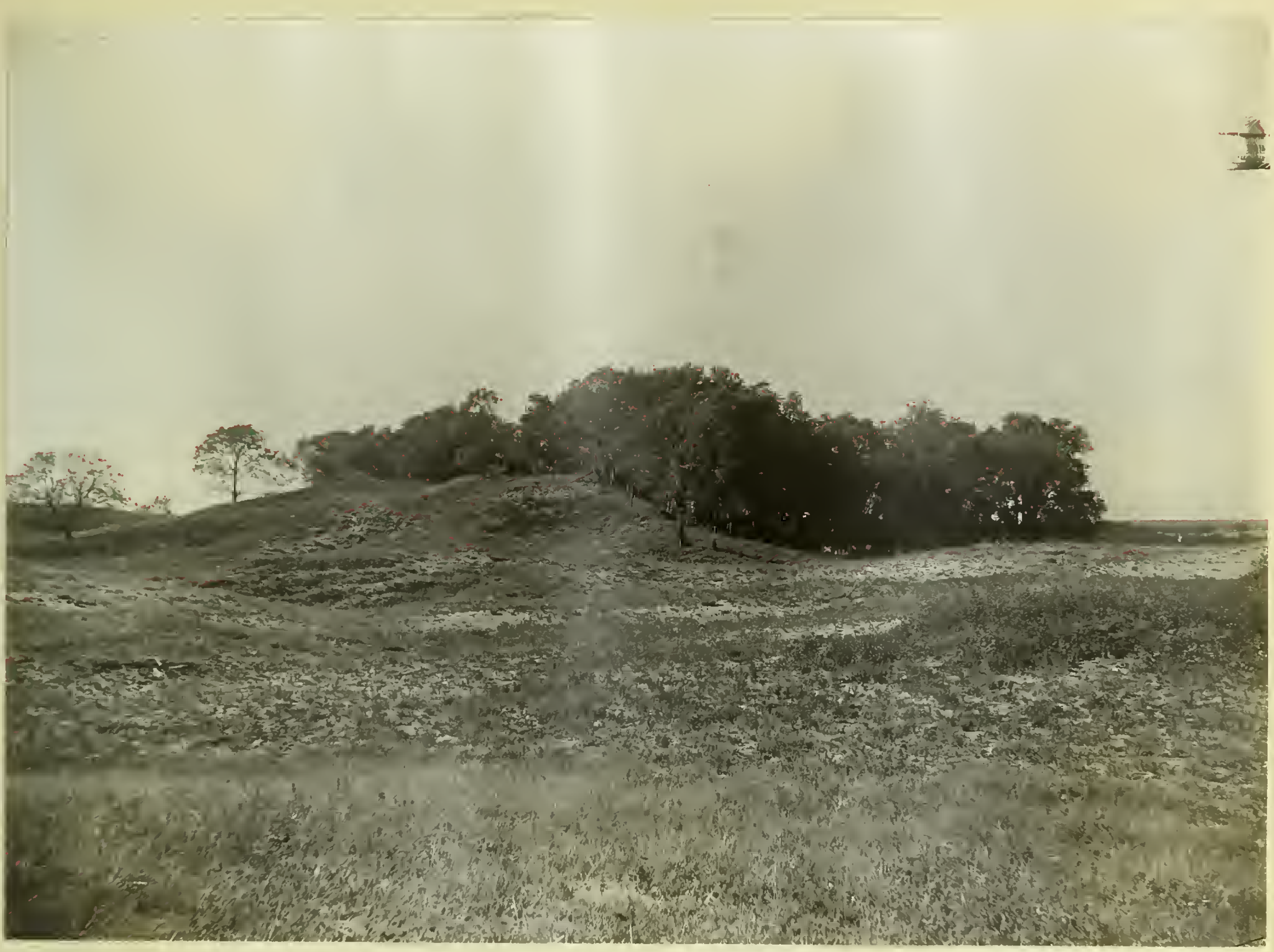

Figure 8.

Dune topography in the bunch-grass of the Devil's Hole. The open character of the association is easily recognized.

Michx., *Aster sericeus* Vent., *Tephrosia virginica* Linn., and *Chrysopsis villosa* Nutt., *Petalostemum* (2 species), *Physalis virginiana* Mill *Baptisia bractata* (Muhl.) Ell. The shrubs of the association may be classed with this group. They are: *Rhus canadensis* var. *illinoensis* which form dense masses, often building up small dome-shaped dunes; *Amorpha canescens* Pursh., *Ceanothus americanus* Linn., with large woody roots.

The second group, the mat plants, ia a small one, including only *Opuntia rafinesquii* Engelm., the common prickly pear, and a species of *Antennaria*.

The interstitial plants are usually annuals, and as the slender stems occupy very little space, they have no part in the binding of the sand. They are absolutely dependent upon the bunch-grasses. The commonest of the interstitials are: *Oenothera rhombipetala* Nutt., *Ambrosia psilostachya* DC., *Linaria canadensis* (Linn.) Dumont, *Cassia chamaechrista* Linn., *Monarda punctata* Linn., and *Croton glandulosus* Linn., var. *septentrionalis* Muell. Arg.

The animals of the bunch-grass association may be classified in the same way as the plants; the dependencies and local distribution of the animals are very similar to those of the plants, though perhaps not so readily recognized. Most of the plant-eating animals, which in the sand-prairie are mostly insects, and the sedentary and phytophilous * predaceous species, are found on the bunch-grasses and mat plants, which will be remembered as the dominant growth form. Other animals do not occur in the clumps of grasses, but are found

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* Phytophilous species are those which live upon, or normally rest upon, plants, as for instance crab-spiders or plant lice.

on the bare sand spaces between. These animals are for the greater part predaceous forms; all are geophilous **, and represent more the fauna of the bare sand than that of prairie growth. We thus have the typical prairie forms or grass species, and the interstitial forms or sand species. The distinction is fundamental, because for many small animals there is no important environmental difference between the interstitial patches of bare sand and the large bare areas which conform to our concept of the blowsand association. Each sandy space between tufts of bunch-grass is a small blowsand association, and numbers of blowsand animals are attracted to it. The whole bunch-grass area is thus a composite association, composed of a number of small prairies and a number of small blowsand associations. This distinction must be kept in mind as we study the bunch-grass association, which is composed of two elements - prairie species, and sand species. The prairie forms, which are dominant, will be discussed first.

The prairie forms include not only the phytophilous species, but those geophilous forms which feed upon the plants. The grasshoppers of the subfamilies Oedipodinae and Acridiinae are characteristic geophilous plant-feeders. These grasshoppers, with the phytophilous Tryxalinae, are foremost among the dominant insects of the bunch-grass: they form the principal food supply for most of the predaceous species of the association. In descending order of importance, the typical bunch-grass Orthoptera are:

Melanoplus angustipennis
Spharagemon wyomingianum
Ageneotettix scudderi
Hippiscus phoenicopterus
Psinidia fenestralis
Mermiria bivittata
Eritettix sp.
Mestobregma thomasi
Melanoplus atlanis
Campylacantha olivacea
Schistocerca alutacea
Scudderia texensis
Mermiria neomexicana
Amphitornus bicolor
Hippiscus haldemanii
Syrbula admirabilis
Conocephalus robustus
Hippiscus rugosus

** Resting normally upon the bare ground - the opposite of phytophilous.

The Orthoptera are apparently the most successfully adapted grass-eating insects. The grassland formation is of primitive type: the grasshoppers are very old forms of insects and the time has been ample for an intimate adaptation of the locusts to grass food. The abundance of the individuals, the rapid rate of reproduction, the adaptation to adverse winter conditions by means of the annual life cycle, with the inactive stage in the winter, the indifference as to food plant - are characteristics of these dominant forms. They are the dominant and most abundant grass-eaters, in spite of their lack of specialized habits and adaptations for defense from their enemies and from severe physical conditions.

Many other insects, though less conspicuous, are also well adapted to grass food. Numbers of phytophagous Hemiptera are preëminently grass-eaters. Among these are many of the Homoptera, particularly the Aphididae, a number of the Heteroptera, including part of the Pentatomidae, the Lygaeidae, the Capsidae, and others. The collections do not show many of the typical grass-eating Hemiptera; these would be brought out only with more intensive study. Many species in the Illinois sand region are more typical of the surrounding country than of sand-prairie. The most important species are:

Phytophagus Hemiptera of the Bunch-grass

Tettigidea hieroglyphica
Scolops grossus
Agallia sanguinolenta
Lygus pratensis
Ligyrocoris sylvestris
Lygaeus bicrucis
Euschistus variolarius
Pentatoma persimilis
Peribalus limbolarius
Corimelaena ciliata

The plant-lice are strangely rare in the sand-prairie. In black-soil prairie they are the food supply for an extensive assemblage of small insects.

The plant-eating species of the bunch-grass also number many

beetles. Among these are a few ground beetles, normally carnivorous, but to some extent eaters of seeds. Other species live in the roots of grass, some feed on the leaves, some bore in stems of herbaceous plants, others are pollen feeders. Some of the beetles are:

Phytophagous Beetles of the Bunch Grass.

Pterostichus lucublandus
Amara cupreolata
Harpalus
*_Anisodactylus rusticus_
*_Languria bicolor_
*_Lacon rectangularis_
*_Cardiophorus_ spp.
Acmaeodera spp.
Lachnosterna implicita
*_Polyphylla hammondi_
Anomala sp.
*_Strigoderma arboricola_
Cotalpa lanigera
Euphoria inda
Trichius piger
Batyle suturalis
Strangalia luteicornis
*_Lachnosterna prunina_
*_Mecas pergrata_
*_Dectes spinosus_
*_Plectrodera scalator_
Tetraopes spp.
Metachroma spp.
Calligrapha similis
Melasoma spp.
Diabrotica spp.
*_Blepharida rhois_
Oedionychus spp.
Disonycha spp.
Bruchus spp.
*_Epitragus acutus_
*_Phacepholis_ spp.
Lixus spp.
Rhyssematus lineaticollis
*_Chalcodermus collaris_
Centrinus picumnus

Lepidopterous larvae, particularly the cutworms, are of great importance as plant-eating members of the bunch-grass association. Some of the Diptera and Hymenoptera which visit flowers feed upon the honey and pollen; many species do not eat plant food.

Among the higher animals which are classified as phytophagous forms, the boxturtle, _Cistudo ornata_, represents the reptilia. Its food is partly vegetable and partly animal. The seed-eating birds are the quail, _Colinus virginianus_, the vesper sparrow, _Pooecetes gramineus_, the lark sparrow, _Chondestes grammacus_, the dickcissel, _Spiza americana_, and the western meadowlark, _Sturnella neglecta_. (See p. 161) These birds eat, besides seeds, large numbers of grasshoppers, during the summer. The prairie white-footed mouse is a vegetable-feeder.

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* The species marked with an asterisk are of special importance.

It is so numerous in the bunch-grass that it becomes one of the principal plant eating species. The pocket-gopher, Geomys bursarius, and the common rabbit, Sylvilagus floridanus mearnsi, are two other vegetarian species. The rodents are active all winter, so that they are of great influence.

There is a division of labor among these plant-eaters of the bunch-grass association. Every part of the plant, and each different kind of plant, is attacked by some animal or groups of animals especially adapted for the purpose. The grass roots are attacked by cut worms, beetle larvae, pocket gophers, and other animals. The juices are extracted from the stems of the plants by the sucking mouthparts of Hemiptera; certain larvae bore in the stems, the grass-blades themselves are eaten by the Chrysomelidae, lepidopterous larvae, the grasshoppers, the prairie white-footed mouse, and the rabbit. The various flowers in the bunch-grass are visited by plant-feeding insects, which live on the honey and pollen, and which usually aid the plant by pollenating it. Fruits and berries are eaten by the box-turtle, by insects, birds, and the prairie mice. The seeds are eaten by Bruchids, certain Carabidae, birds, and rodents. Decayed parts of plant remains are eaten by various scavengers, notably Dipterous larvae. When more is known of the habits of each animal species, we will be able to determine exactly the function of each animal in the association, and its ecological relations to other animals and to the plants.

This division of labor - the adaption of certain species or groups to fill a definite place in the association - is carried out to a high degree of specialization in certain forms, and in others the life-needs have a wide range of elasticity. The moderately

specialized forms probably constitute the large majority of the animals in an association. These forms are not restricted to a single food plant, although they may be seen to show preference to one particular kind of food. The highly specialized forms are enabled to avail themselves of opportunities denied to the generalized forms; they thus avoid competition, but lose the versatility, if we may call it so - the ability to adapt themselves to changed conditions - that the less specialized animals have. They may thus become abundant at times, but as they depend wholly upon one variable condition - perhaps the presence of a particular plant which may be quite rare in the association - they never can become dominant species. The insects which live upon *Cacalia* - the plant bug *Lygaeus bicrucis*, and the stem-borer *Languria bicolor* are such species; they are conspicuous, but occupy a very insignificant place in the association because *Cacalia* is relatively a very infrequent plant, and the absolute numbers of such specialized forms is insignificant in comparison with such animals as the grasshoppers. On the other hand, the forms of extremely generalized habits are also unimportant, for usually whatever field of activity they enter, they find already occupied by some species better adapted to the end in view. The chief function of the species of generalized habits is that of regulators of disturbances in the association. Such forms are more often predaceous or omnivorous species; these will be discussed later. Functionally, therefore, it seems that the animals of the bunch-grass (or of any other association) are divided into three groups, the moderately specialized forms, which carry on the ordinary work of the association; the highly specialized forms, which make use of space otherwise unoccupied and food material not demanded by other species; and

the animals whose habits are elastic, which act in opposition to forces tending to destroy the biotic equilibrium. The dominant animals of the association are those of the first group.

The functional classification of the animals of an association includes the predaceous forms as well, and those of the bunch-grass will now be discussed. The majority of the predaceous species are interstitial; their presence is in large part due to the presence of the open spaces of sand. Those which are present because of the grasses, and which are not regularly found on the bare sand, form the second element of the predaceous species. A third element is derived from neighboring associations; a certain quota of invaders from the outside is present in all associations, particularly if the surrounding associations are of radically different type. We can thus recognize the aquatic element, the forest element, and the ruderal element, from the neighboring fields under cultivation.

The interstitial predaceous forms are listed as follows, with the more important species marked by an asterisk. Underground species are followed by U in parentheses.

Interstitial Predaceous Species of Bunch-grass.

*Lycosa fatifera
Other lycosids
Phidippus insolens
Fitchia aptera
Stachyocnemis apicalis
Alydus spp.
Myrmeleonid larvae
*Cicindela formosa generosa
*Cicindela scutellaris lecontei
*Cicindela larvae (U)
Pasimachus elongatus (U)
*Geopinus incrassatus (U)
Nothopus zabroides
Harpaline larvae (U)
Harpalus spp.

*Anisodactylus rusticus
*Opatrinus notus
Blapstinus interruptus
*Proctacanthus brevipennis
*Proctacanthus rufus
*Pheidole vinelandica
Sphaeropthalma occidentalis
*Sphaeropthalma chlamydata
Other mutillids
*Ammophila spp.
*Tachytes spp.
Other sand hymenopters
*Cnemidophorous sexlineatus
*Cistudo ornata
*Heterdon nasicus (see p. 150)

Species of western distribution are conspicuous in this list, which will serve very well for the list of blowsand species, with the addition of one or two species.

The predaceous species which owe their presence directly to the plants (phytophilous forms) are as follows:

Phytophilous Predaceous Species of Bunch-grass.

*_Xysticus gulosus_
Epeira stellata
*_Phidippus audax_
Oecanthus confluens
Reduveolus ferus
*_Sinea diadema_
Phymata fasciata
*_Perillus circumcinctus_
Chrysopa larvae
Pterostichus lucublandus
Amara cupreolata
Harpalus caliginosus
Megilla maculata
Coccinella 9-notata
Hippodamia parenthesis
Trichodes nuttalli
Odynerus spp.
Other Hymenoptera
*_Sturnella neglecta_ (see p.161)
Poocetes gramineus
Chondestes grammacus
Spiza americana
Scalopus aquaticus
Mephitis mesomelas avia

The species listed above are true prairie forms, and all, except possibly one (_Sturnella neglecta_), are found in the closed prairie formations of other parts of Illinois. With the development of the bunch-grass into a closed formation, all the interstitial species are excluded. In the present open state of the bunch-grass, the prairie species are greatly subordinated by the interstitials, which include the dominant predaceous forms.

The parasitic bunch-grass animals are very poorly represented in the collections. They are:

Parasites in the Bunch-grass

Parasite	Host
Trombidium locustarum	Acridiidae
Anthrax spp.	Acridiidae and cutworms
Systoechus vulgaris	Acridiid eggs
Gonia frontosa	Lepidopterous larvae
Spallanzania sp.	Lepidopterous larvae
Apanteles sp.	Lepidopterous larvae

In addition to the above, there is an undetermined hymenopterous parasite, without wings, found in the nest of the sand-inhabiting ant _Pheidole vinelandica_. Mr. Girault thinks that the species has not been described. A large number of parasites, particularly those affecting the grasshoppers, would be found in a more intensive study of the bunch-grass association. The parasites though highly specialized, might be classed with the non-specialized types as regulators of disturbances within the association. They are much less adaptible, however, for they parasitize only a single species, or else a small group, and it is only when the species or group becomes very abundant that they act as regulating species. The parasites _as a class_ do less to preserve the balance of dominance than do the ordinary predaceous species, for these exercise greater variability in food habits. The parasites, then, I should include functionally with other highly specialized forms, as secondary members of the association.

The discussion of the derived elements of the bunch-grass - the invaders from other associations - need be little more than mere lists. The presence of the river exerts a very great influence upon life conditions for some miles from its banks. Some of the invaders from the river are:

*_Hexagenia_ spp.
Ischnura verticalis
Sympetrum rubicundulum
*_Perithemis domita_
*_Chironomid_ spp.
*_Bufo lentiginosus_

The forest forms which invade the prairie are quite numerous. Certain species more properly belong to xerophytic thickets which are more typical of the prairie region than of the forest. Some of these are listed below:

The Derived Forest Element of the Bunch-grass.

Ischnoptera inaequalis
Melanoplus scudderi
Carabid spp.
Limonius quercinus
Chrysobothris femoratus
Lucanus placidus
Batyle suturalis
Xylopinus saperdioides
Tyrannus tyrannus (t)
Cardinalis cardinalis (t)
Mimus polyglottos (t)
Toxostoma rufum (t)

(t) indicates invaders normally of thicket associations. This list gives only a very few of the forest species which are found occasionally in the bunch-grass.

The ruderal and cultural species which get into the sand-prairie are very numerous. Much of the bunch-grass is pastured; two horses are seen in the Devil's Hole pasture on figure 7 (p.40). The horses and cattle are of very great influence upon the association. Cactus, the shorter bunch-grasses, *Bouteloua* and *Leptoloma*, and such bitter herbaceous plants as *Monarda punctata* and *Ambrosia psilostachya*, are unusually abundant in bunch-grass that has long been pastured - the longer grasses become very scarce, and the plants which are not eaten at all become dominant. A very large number of scarabaeid scavengers are attracted to the bunch-grass as a result of the presence of the cattle. Some of these beetles are found in the burrows of small mammals, but probably none of the species are restricted to this habitat. The carrion-feeding scavengers, denoted by C in parentheses, are included in the same list for convenience. Those found only in mammal burrows are designated by B in parentheses.

Scavengers in the Bunch-grass.

Necrophorus marginatus (C)
Silpha inaequalis (C)
Canthon vigilans (B)
Canthon nigricornis (B)
Canthon laevis
Copris carolina
Onthophagus pennsylvanicus
Aphodius fimetarius
Aphodius inquinatus
Aphodius terminalis
Geotrupes opacus
Trox scabrosus (C)

There are a number of other scavenger species. Besides the scavengers which are present because of the cattle, many other species of the bunch-grass may be traced to ruderal or cultural conditions in the bunch-grass, or in the adjoining fields. The list follows:

Ruderal and Cultural Species of the Bunch-grass

Lygus pratensis
Adelphocoris rapidus
Megilla maculata (?)
Coccinella 9-notata (?)
Hippodamia parenthesis (?)
Drasterius elegans

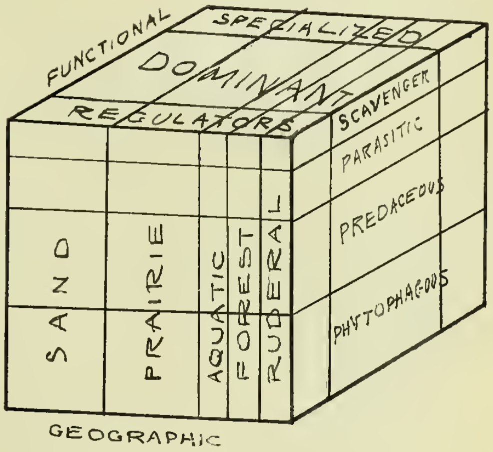
Leptinotarsa 10-lineata
Diabrotica spp.
Phytonomus punctatus
Feltia subgothica
Musca domestica
Passer domesticus

The preceding pages have given us what might be called an analysis of the animals of the bunch-grass. With so many species involved this is perhaps the most satisfactory method of discussion in a limited space. The analysis might be extended with tables showing the local assemblages of animals, such as the animal groups found on certain food plants, but as these assemblages have already been very graphically treated by Mr. Hart (1907: 220-227), their description is omitted here.

A summary of the grouping of the animals of the bunch-grass association would show a tri-dimensional analysis. The first division, on the basis of food, throws the animals into four classes: phytophagous, predaceous, parasitic, and scavenger. The second division, on the basis of geographic relations, groups the animals into three elements: the sand element (largely interstitial, predaceous forms of western distribution), the prairie element (phytophilous forms, usually ranging to the Atlantic coast and found in the closed prairie formations), and the derived element, consisting of invaders from the river, from the forest, and from ruderal and cultural formations. The third or functional division is on the basis of the ecological status of the

species in the association. There are three groups, (1) the dominant group, the members of which carry on the gross metabolism of the association - there is a general division of labor in this group -, (2) the specialized group, in which the metabolic economy is carried out in detail - the members are highly specialized in habits, in food, and in distribution -, and (3) the "regulator" group, consisting of animals of elastic habits, food, and distribution, which, by following the path of least resistance, tend to minimize the amplitude of oscillations of dominance. Professor Forbes' paper on "The Regulative Action of Birds upon Insect Oscillations" (1883), illustrates very clearly the way in which species of generalized habits restore unbalanced conditions to equilibrium.

The tri-dimensional analysis of the association may be represented graphically in a very simple manner. as shown in the diagram. It is almost self-explanatory; each species has a more or less definite position on each ordinate, and the position of the animal in the association is represented by a corresponding position within the cube.



A Graphic Representation of the Constitution of the Bunch-Grass Association

With a little modification, the analysis may be made to include the plants of the association as well as the animals, and this is the desired method in associational studies.

The functional grouping is the one we know least about, and is the most difficult to study. It has been merely hinted at in the

present study, but it would seem that the mere recognition of such a grouping is a suggestive step toward the formulation of the criteria of dominance and an orderly and analytical knowledge of the constitution of the association.

THE PANICUM PSEUDOPUBESCENS ASSOCIATION.

The dominating factor in the Panicum pseudopubescens association is the wind, which has gained control over the plants, and is now destroying the vegetation. This association is merely the transition stage in the succession from bunch-grass to blow-sand, and is marked by a large proportional area of bare sand,which is constantly being removed by wind. The association is very commonly found on dune summits, where wind exposure is pronounced.

Panicum pseudopubescens is the last bunch-grass species to be killed by the removal of sand from its roots. It seems to thrive better under conditions of sand removal than in more stable sand, in competition with the other bunch-grasses. It thus becomes the dominant plant of the association. A few other bunch-forming species persist in this association as relics from the bunch grass; some of these are Panicum perlongum, Andropogon scoparius, Koeleria cristata, and Cyperus schweinitzii. The secondary species are perennials, which persist as relics, and interstitials, which are very well developed in this more open association. The species are nearly all the same as those of the bunch-grass.

The animals do not differ greatly from those of the bunch-grass. The phytophilous species which live in the bunches are not as well represented, but the interstitial species and those more characteristic of the the blow-sand are very much more abundant than in the bunch-grass. On the whole, the animals may be said to form a group which is transitional between the animals of bunch-grass and those of blow-sand. The tiger beetles, mutillids, sand-

wasps, and geophilous grasshoppers are more numerous than in the bunch-grass. The structure of the animal assemblage is thus seen to be parallel with that of the plant assemblage.

THE CLIMAX SAND-PRAIRIE ASSOCIATION.

This association is not well represented in Illinois, for the reason that in it, or even before its development, the soil has reached such a stage of fertility and stability that it is suitable for agriculture, and only the more open associations have been allowed to remain in a natural state. This stage is a relative or temporary climax, rather than an absolute and permanent climax; it is merely the end of the sand series. It probably connects the sand-prairie to the prairie-grass or black soil prairie formation of the eastern part of the province, and doubtless many relics of an association very much like it may be found in the tension zone between the plains and the prairie-grass regions. The normal tendency is for the climax sand-prairie to develop slowly into a stage of the black-soil prairie; under natural conditions this development would never occur in the Havana region, for invasion by the forest would be much too rapid for the succession between the two prairie formations to take place. Thus in the Havana region we find much of the area forested, but never an index of the true black-soil prairie. The large rosin weeds, Silphium, and the peculiar umbellifer, Eryngium yuccafolium, so characteristic of black-soil prairie, are conspicuously absent from the Havana sand-regions, never being found even in the flats of sandy loam. Other species of animals and plants, however, were found in certain localities, which indicate an approach to mesophytic conditions. Plate XVII

in the report of Hart and Gleason represents a closed or nearly closed prairie association of very dense growth. This was located near the Devil's Neck. The former island on which the Devil's Neck is located was once entirely sand-prairie, and is now largely cultivated, the soil being quite fertile in most places. Quite probably much of the sand-prairie on this island reached an advanced stage, and the association figured by Hart and Gleason is a remnant of it. The walking-stick Bacunculus blatchleyi Caud. was taken by Mr. Hart in this prairie growth - the species is more typical of rather dry black-soil prairie than of sand-prairie - I have no other record from a sand region. This prairie growth near the Devil's Neck may therefore be referred to a more advanced stage of sand-prairie than the bunch-grass association.

Several localities just east of extensive tracts of forested dunes show an approach to climax prairie conditions. It may possibly be that wind action has been less on the lee side of these dunes, especially since they have become forested, and that the stability favored rapid development. At any rate one finds, east of the dune complex near Quiver Station, such forms as Cicindela punctulata, Melanoplus differentialis, M. bivittatus, the dickcissel (Spiza americana), the indigo bunting (Cyanospiza cyanea), the goldfinch (Astragalinus tristis), and ruderal roadside plants, all scarce in the typical sand region, and indicative of mesophytic conditions. The soil was also conspicuously darker there. At the east border of the Matanzas lake marginal forest, a flat stretch was found in which were Phymata fasciata, Arphia xanthoptera, Melanoplus bivittatus, M. differentialis, and plants such as Asclepias syriaca, and Pycnanthemum. These are species more or less dis-

tinctive of rather dry prairie of the black-soil type.

Appearances thus indicate that there is such an advanced sand-prairie association, even though most of it has been plowed up. It has occurred to me that a very similar association may occur in parts of the Lake Michigan sand region. In several localities there, notably in the neighborhood of Calumet, Indiana, there is a series of very narrow dune ridges, alternating with swales or sloughs, usually filled with water. These ridges are of lake origin and are roughly parallel with the shore line. The plants are dense grasses; cactus relics are very scarce, if at all present in this particular locality. The commonest tiger beetle of the region is Cicindela scutellaris lecontei, which species is restricted to sandy soil containing a considerable proportion of humus. A future visit to this region will no doubt reveal important relations in the development of the association.

The climax sand-prairie association in the Havana region is the continuation and culmination of the processes resulting from the dominance of the vegetation: (1) the elimination of the interstices between the bunches of grass, and with these the interstitial plants and animals, thus changing the loose tuft growth into a dense sod, (2) the gradual accumulation of humus, (3) the increasing capacity of the soil for water storage, and (4) the increase of atmospheric humidity. With the closing of the association most of the perennials, including the cactus, would be eliminated as well as the interstitials. There is then the tendency towards the dominance of a few species of plants and animals, rather than of numerous species. It is quite probable that only the early stages

of the climax sand-prairie have developed in the Havana region - otherwise we should expect to find relics of the advanced stage more abundantly. Again, under natural conditions we should expect the successional series of the sand formation - the sand prairie - , and the series of the swamp formation of the sandy loam flats - the swamp-prairie - , to converge ultimately in an advanced mesophytic stage common to both series. I have seen no indication of such convergence, though it is not improbable that associations may be found intermediate between the sand-prairie and the swamp-prairie. It seems certain, however, that the process of stabilization and accumulation of humus which characterize the bunch-grass do not culminate in that association, and that there is a natural and gradual succession between the sand-prairie formation and the prairie-grass formation typical of the eastern part of the prairie province.

THE BLOWOUT FORMATION .

The distinguishing feature of the blowout formation is the dominance of the physical environment. The wind exercises complete or almost complete control of the vegetation. The formation is so open that its general appearance and color is that of almost bare sand. The associations,being subordinated by the physical conditions, are distinguished from each other by differences in physical environment - the difference in plant and animal species is an effect rather than a cause. Changes in the life are determined by changes in the physiography. In the prairie formation the normal changes in the physical conditions are largely the work of the plants. Even the names of the associations have been

taken from physical features. The prevailing tendencies are the continually shifting of the sand, which is thus kept in a sterile condition, the formation of blowouts and dunes in places where the vegetation is or has been of influence in modifying the action of wind (fig. 11, p. 65 ; fig. 8 , p. 41), and the formation of large, nearly level sandy wastes, wherever the wind has long been the controlling factor.(fig. 9, p. 61; fig. 18 , p. 175). This latter "blow-sand" conformation is due largely to the confluence of a number of bloweuts, but is very characteristic, and covers in the Havana region many times the area of the isolated blowouts. Gleason's discussion of the formation of the blowouts is without doubt the best we have (1910:84-90).

The blowout itself is a wind-formed excavation, normally originating in the Panicum pubescens association by gradual ascendency of the influence of wind, resulting in increasing openness of the association. Blowouts sometimes start in the bunch-grass, usually by accident. Figure 10 (p. 62) shows the beginning of a blowout on the slope of the dune to the left, A small bare expanse from which the wind is gradually removing the sand is the first stage of the blowout. It gradually deepens, the sand from the basin of the depression being deposited above the general level on the lee side. The deepening continues, the sides of the depression become steeper, except the lee slope, up which the sand is drifted and deposited as a low dune formation. The windward slope reaches the critical angle, and from then the removal of the sand from this side of the depression is by gravity. There are thus four physiographic divisions of the blowout, (1) the basin, from which sand is being removed by wind; (2) the windward slope, from which sand

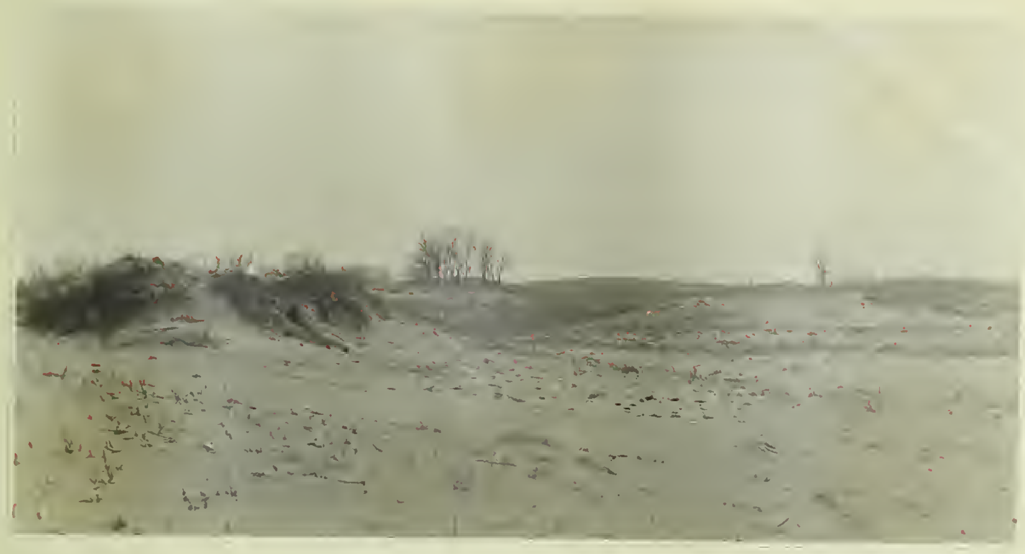


Figure 9.

An area of bare sand showing the very sparse vegetation. The Rhus dune to the left is being blown away by the wind.

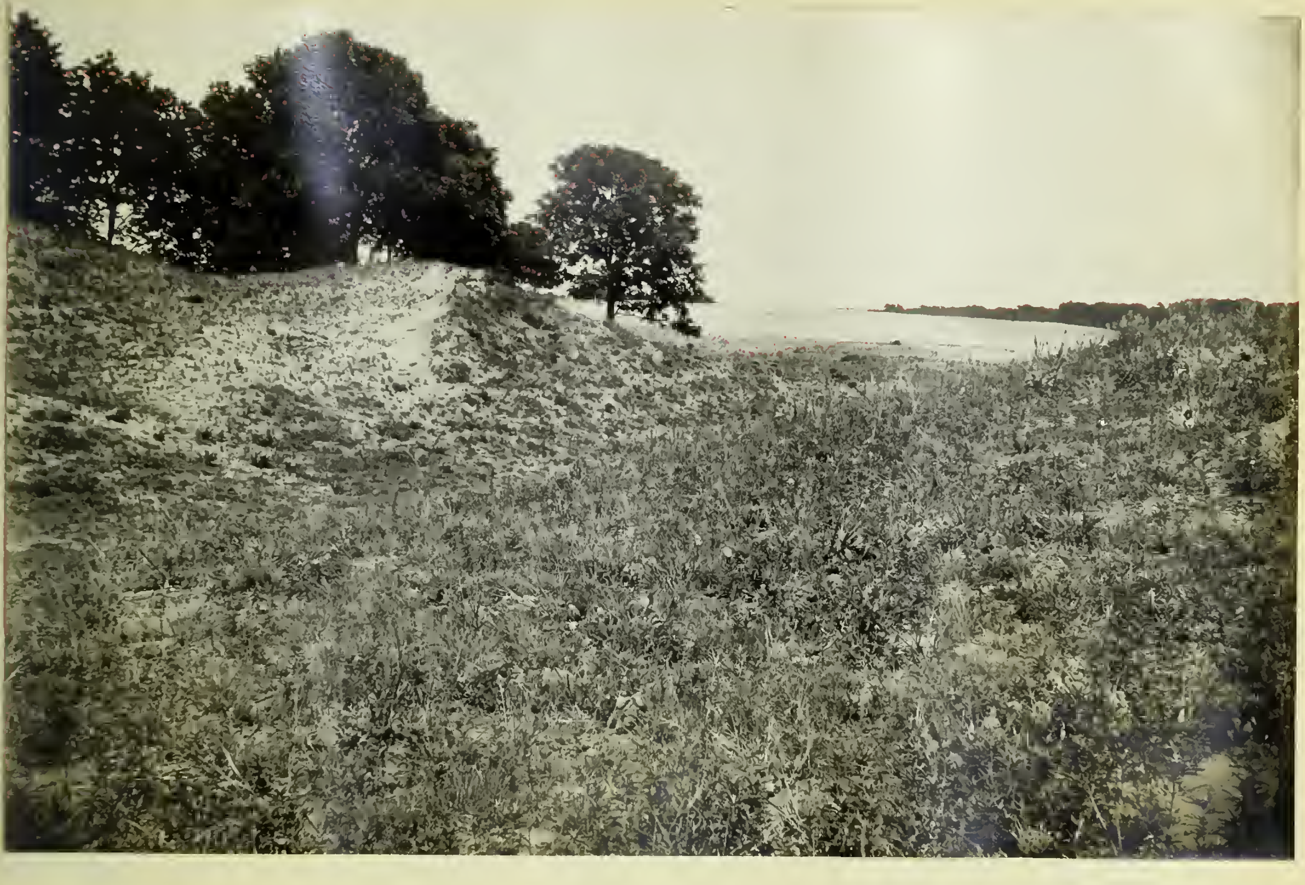


Figure 10.

Bunch-grass at the Devil's Hole. The bunch-grasses and the cactus are easily discernible. Wind action is starting on the slope to the left. Beyond is a very large blowout.

is being removed by gravity; (3) the lee slope, or blow-sand division, over the surface of which the sand is being merely drifted, without change of level; and (4) the deposit, which is continually being added to by sand from the basin. The differences between these physiographic divisions are reflected in the plants and animals which inhabit them; the groups are sufficiently distinct to be different associations, which take their names from the physical divisions of the blowout.

Plant growth in the blowout formation is extremely scanty - few plants are adapted to the severe physical conditions. Most of the plants are slender annuals - the species composition is almost the same as that of the bunch-grass interstitials. A few perennials sometimes persist as relics from former bunch-grass. The animals are usually species which are normally restricted to sandy habitats. the plant-feeders are very poorly represented, as would be expected in such sparse vegetation. Most of the animals are wandering predaceous forms, which make regular incursions into the adjacent bunch-grass. Very large stretches of bare sand have almost no animals, except about the margin. The action of wind upon loose sand thus tends to establish the physical and biotic conditions of a desert.

The Basin Association

The basin association occupies the circular or oval area in the bottom of the blowout, from which the sand is being removed by wind (fig. 11, p.65). Plants which persist in the basin must therefore be able to withstand excavation. The only plants that can withstand undermining to any appreciable extent are the green milkweed, *Acerates viridiflora* Ell., and its variety *lanceolata* (Ives) Gray, which thrives even better than the type. These plants are sometimes found in bunch-grass or in the *Panicum pseudopubescens* association, but are much more numerous in the basins. The roots are very long, the plant lies procumbent upon the sand. The blowout basins of the Nebraska sand-hills are usually grown over with the grass *Redfieldia*. A few perennials persist in the basin if the sand removal is not too rapid. These are *Lithospermum gmelini*, *Euphorbia corollata*, and *Lespediza capitata*.

Animals of the basin are principally invaders from neighboring associations. The blow-sand animals and interstitials from the bunch-grass make frequent incursions. At the margin of the *Cassia* zone are seen many mutillids, wasps, and spiders. The basin has several distinctive species. Sand wasps of the genus *Tachytes* hover about the flowers of *Acerates*. *Cicindela lepida* and *Stachyocnemis apicalis*, whose color matches that of the sand, are found all over the bare sand of the basin. *Lycosidae* often burrow in the open sand. *Cistudo* has been taken at the edge of a blowout, and one often finds the tracks of mice, rabbits, and the sinuous trail of the blow-snake crossing the basin. Mutillidae are found in the bare sand, and at the margin are *Schistocerca alutacea* and *Melanoplus flavidus*. Other Cicindelidae than *C. lepida* are quite frequently taken in the basin. *Alydus*, the

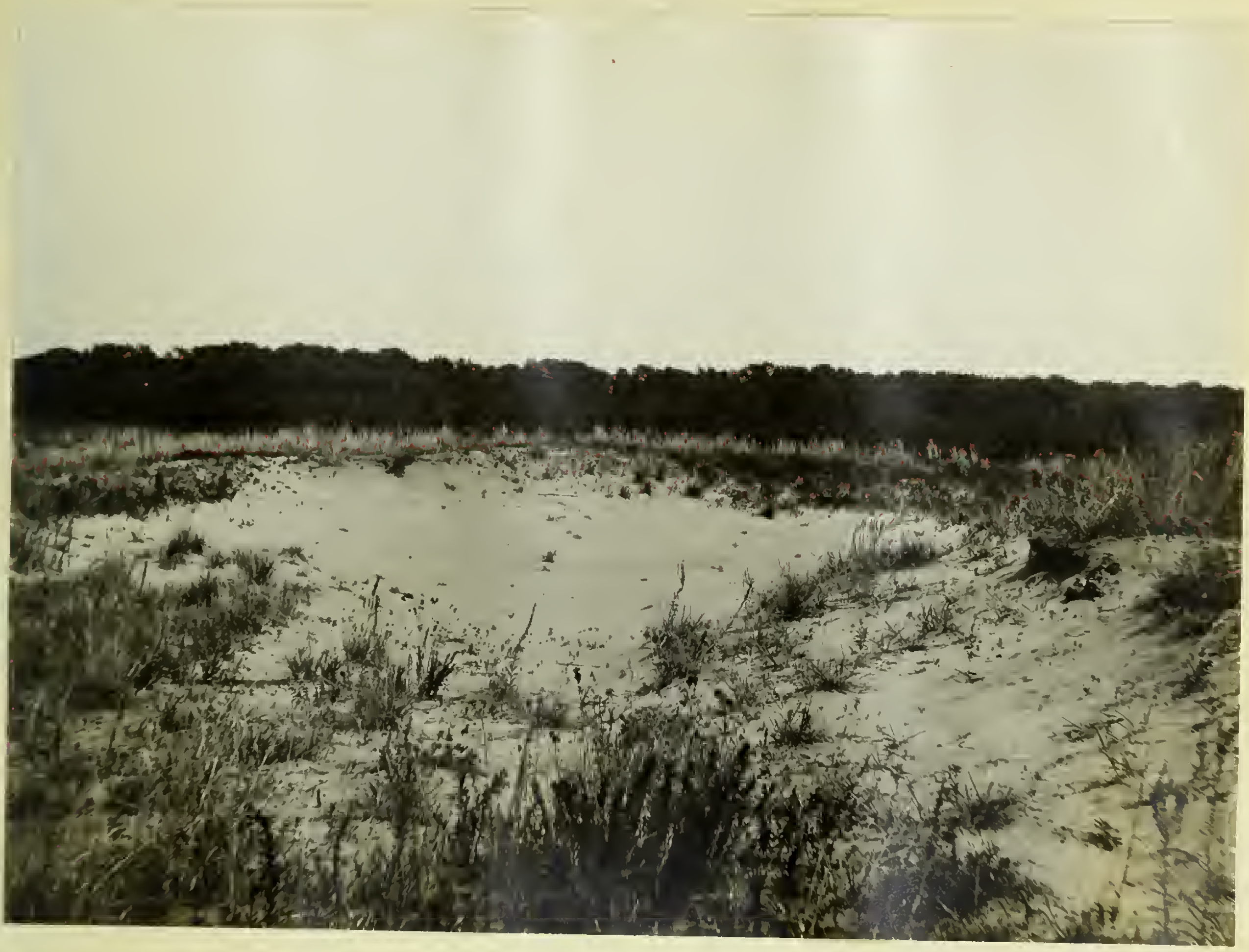


Figure 11.

A nearly typical blowout at the Devil's Hole. The basin is shown in the center, the windward slope at the right, and the blowsand association in the right back ground. The forest in the background is the black oak of the ridge between Crane Creek and the Black-jack Ditch.

peculiar ant-like bug, is represented by several species. Like the plant life of the basin association, the animal life is very scanty, and represents the extreme conditions of combined effect of wind and sand.

The Windward Slope Association

The windward slope of the blowout is quite steep, and the sand is continually sliding down by gravity. Usually the top of the slope is held by plants of the bunch-grass growth which more often adjoins the blowout (fig.11, p.65). In an active blowout the sand which falls to the bottom of the slope is removed by the wind, and the windward slope thus works its way back, enlarging the blowout in the direction of the wind.

No annual plants are found on the windward slope, as there is no chance for burial of seeds. The plants of the association are always in the form of relics from the surrounding associations, usually bunch-grasses. In the Havana region, Sporobolus cryptandrus (Torr.) Gray is often found on the windward slope. Most grasses are killed as soon as they become dislodged from the face of the sand-bluff, but this species seems to grow nearly as well on the steep slope as in more stable sand in competition with other species. A few other grasses and a few perennials are also occasionally found on the windward slope. The tufts of grass are always very few and scattered - sometimes the wholeface of the slope is altogether bare. The grasses sometimes become a part of the basin association, after reaching the bottom of the slope but more often they are undermined and blown away.

The animals of the windward slope association are very few indeed, and the forms that are found are accidental species. Burrowing animals are excluded, because of the instability of the sliding sand.

Many animals, however, cross the windward slope areas, and practicall all the animals of the bare sand are seen there, particularly _Cicindela lepida_, _Stachyocnemis_, mutillids, and spiders. The windward slope is very closely related to the basin association; the same process is involved in each association - the removal of sand - and the biotic conditions approach those of the desert in each area.

THE BLOWSAND ASSOCIATION.

This association occupies the lee slope of the blowout, which is of gentle gradient. The sand movement is merely a drifting in the direction of the wind, with but little removal or deposition of the sand. The constant shifting of the surface layer may allow annual plants is not always present. The plant species found on the lee slope of a nearly typical blowout at the Devil's Hole are as follows: *Cassia chamaechrista* and *Ambrosia psilostachya* are the two commonest species. *Cenchrus carolinianus* and *Aristida tuberculosa* are the two annual grasses; tufts of *Sporobolus cryptandrus* are quite common; other annuals are *Oenothera rhombipetala*, *Croton glandulosus* var. *septentrionalis*, *Euphorbia geyeri*, *Froelichia floridana*, *Tephrosia virginiana*, *Cycloloma atriplicifolia*, *Polanisia graviolens*, *Crotonopsis linearis*, *Monarda punctata*, and the western species *Cristatella jamesii*. *Euphorbia corollata* and *Lespedeza capitata* are two perennials sometimes seen on blow-sand. In the other sand regions of Illinois the floristic composition of the blow-sand association varies considerably.

The large sandy wastes are also referred by Gleason to the blowsand association. The origin of these large expanses of bare sand is normally the confluence of a number of blowouts. Often, however, blowing has started in plowed fields, causing their abandonment. The sand then drifts across the level surface, unobstructed by vegetable growth, and the only plants to be found are annuals, especially *Cenchrus* and *Aristida*. It seems that a distinction between the blowsand of the large bare areas and the blowsand of the lee slope of the blowouts may be necessary. Floristic and physiographic differences indicate that these may possibly repre-

the burial and germination of a few of the countless seeds which are blown across the blowouts, and consequently a large number of annual plants are regularly found in this association. The conditions of burial, however, vary from year to year, so that the growth of annual plants is not always present. The plant species found on the lee slope of a nearly typical blowout at the Devil's Hole are as follows: *Cassia chamaechrista* and *Ambrosia psilostachya* are the two commonest species. *Cenchrus carolinianus* and *Aristida tuberculosa* are the two annual grasses; tufts of *Sporobolus cryptandrus* are quite common; other annuals are *Oenothera rhombipetala*, *Croton glandulosus* var. *septentrionalis*, *Euphorbia geyeri*, *Froelichia floridana*, *Tephrosia virginiana*, *Cycloloma atriplicifolia*, *Polanisia graviolens*, *Crotonopsis linearis*, *Monarda punctata*, and the western species *Cristatella jamesii*. *Euphorbia corollata* and *Lespedeza capitata* are two perennials sometimes seen on blow-sand. In the other sand regions of Illinois the floristic composition of the blow-sand association varies considerably.

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sent different associations. In one field a species of Apocynum was the most abundant plant. The large bare sand areas resist stabilization by plants and tend to maintain the physical conditions of wind control. In a sense, then, the blowsand might be considered the climax stage of the blowout formation, for it represents the culmination of the ecological conditions which characterize the formation, and also shows a tendency towards self-perpetuation. On the other hand, by climax stage we usually mean the highest stage of development of the vegetation of the association. The deposit stage would then be the climax of the blowout formation, for it has usually the most luxuriant vegetation.

The animals of the blowsand show a peculiar relation between associations. In some of the lee slope areas in blowouts the growth of annual plants is sufficient to support a considerable animal population. In the large bare areas of sand, however, the plants are very few and scattered; the animals are for the greater part roving predaceous forms. These animals (practically all being insects) are quite numerous, too, and it is seen at once that their food supply must come from outside the blowsand area. It is then observed that in large areas of bare sand the animals are very much more numerous towards the margin, and when it is remembered that the blowsand species are the same as the bunch-grass interstitial species, the conclusion is reached that there must be a continual interflow of individuals between the two associations. The blowsand animals get their food largely in the bunch-grass association: it would seem that the contact between the two associations, one with a much higher food potential than the other, if we may borrow the terms of the physicist, causes a flow toward the area of lower potential. It

would thus seem that the blowsand interstitial animals are members of two associations - at one time they are blowsand animals, at another time they are interstitial members of the bunch-grass association. Is this compatible with our concept of the association? The point is further raised that an association should be self-contained; the anabolic and katabolic elements should be of equal intensity in order to maintain equilibrium. In the blow-sand association the katabolic element is perhaps two or three times as influential as the anabolic element. Can the blow-sand then be an association? This question can best be answered by deferring it until a new question can be disposed of: If the blowsand animals get their food in the bunch-grass association, why do they not stay there - why do they enter the blowsand at all? The answer to this is that all the animals are in reality members of the bunch-grass association - the animals which are now outside, in the bare areas, may have been temporarily crowded out by other individuals - the competition-pressure, again using physical terms, is greater in the bunch-grass association than in the bare sand areas. We must therefore restrict our use of the expression "blow-sand association" to the sparse vegetation of the bare areas, and the scanty assemblage of animals which it may be able to support. It appears further that this impoverished group of animals and plants can hardly be referred to the comparatively luxuriant little association of the lee slope of blowouts - the Cassia zone, which has an abundant growth of annual plants, and a definite assemblage of animals associated with them. This is the true blowsand association and I therefore propose that the term "blowsand association" be still further restricted to this association of the lee slope of blowouts. The large bare areas I should give

the name "sandy wastes" or some such descriptive appellation.

We may now proceed with a brief analysis of the true blowsand association. The plants have been shown to consist chiefly of animals. The animals which feed upon these plants are *Thyreocoris ciliata* and *Bruchus cruentatus*, both of which are associated with *Cassia chamaechrista*. There are also aphids living upon some of the plants quite probably, for I have seen Coccinellidae and ants roaming about the stems as if searching for plant lice. On the flowers of *Cassia* many flies and Hymenoptera were present (*Bombus*, *Odynerus*, *Polistes*, *Tachytes*). The most impostant plant-eating animals, however, are the Orthoptera, which include many of the species of bunch-grass. They are:

Spharagemon wyomingianum
Psinidia fenestralis
Schistocerca alutacea
Melanoplus angustipennis
Melanoplus flavidus
Conocephalus robustus

The predaceous species include three phytophilous species:

Sinea diadema
Coccinella 9-notata
Hippodamia parenthesis

The ground forms are much more abundant; they include:

Lycosa fatifera
Phidippus insolens
Stachyocnemis apicalis
Alydus spp.
Cicindela formosa generosa
Mutillids
Ammophila spp.
Heterdon
Cistudo
Scalopus

The blowsand association as developed on the lee slope of blowouts, though consisting of an abundant growth of plants and animals, is nevertheless quite dependent upon the physical environment, and may be exterminated in a winter of severe wind action. Several times I have seen lee slopes of blowouts with the horizontal roots of last year's annuals exposed at the surface; this indicates that a depth of about three inches of sand has been blown away during the winter.

The Deposit Association

The manner of deposition of sand on the lee side of a blowout is influenced greatly by the vegetation. If none is present the sand spreads out over the general level in a broad thin fan-shaped layer. Plants growing on the lee side of the blowout, particularly if they be bunch-grasses, tend to check the velocity of the wind, which thus is unable to carry its load. Sand is then deposited at the base of the plants. If now the plants, by upward growth, can continue to act as obstacles to the wind, the deposition of sand will continue also and a dune will gradually be built up. The obstacle grows upward with the dune. Many of the sand-prairie plants are efficient dune formers, and these species are quite common in the deposit association. The principal species are Rhus canadensis var. illinoensis, Panicum virgatum, and Tephrosia virginiana. A Rhus dune, the side of which is being undermined by a large blowout, is shown in Figure 9 (p. 61). The process of dune-formation at the lee side of blowouts is now well shown near the Havana region; the deposit associations are not typical, and so very little study has been given them. A study of the animals of the association was not even attempted, but the general character of the assemblage is transitional between the animals of the blow-sand and those of the bunch-grass. Future work in the other sand areas should include a study of this association.

The deposit association is acted upon by two tendencies - the stabilizing action of the vegetation and the destructive action of the wind. The succession proceeds in either direction, depending upon which set of conditions predominates.

SUCCESSIONAL RELATIONSHIPS IN THE SAND-PRAIRIE.

Most of the Illinois River sand area was covered originally by the bunch-grass. The natural process of vegetative development caused a gradual change in part of the area, until the climax stage was reached. In other places, where the exposure to the wind is considerable, the sand between the tufts of grass is blown away, and the Panicum pseudopubescens association results. Continued wind action in parts of this association results in the formation of blowouts. The successions between the basin and the blowsand associations, and between the blowsand and the deposit associations, may take place in either direction. The confluence of a number of blowouts may cause the development of large sand wastes. These may also result from accidental causes. Stabilization by the bunch-grass may occur in any association of the blowout formation.

The forest formation succeeds the sand-prairie either through the black-jack oak or the black oak association. The association invaded is usually the bunch-grass, though the large areas of nearly bare sand may perhaps also be directly succeeded by forest growth. In this type of succession a sand-thicket stage consisting of Rhus, Ptelea, Robinia, Populus, and other species would probably intervene. The successional relationships are shown graphically in Gleason's bulletin (1910:133) by means of a diagram.

VI. NOTES ON GEOGRAPHIC AND ECOLOGICAL RELATIONS OF THE ANIMALS.

A comprehensive geographic and ecological treatment of the sand-prairie animals has not been attempted in the present study. In the preparation of the annotated list, however, certain intersting features of the sand-prairie fauna were impressed upon me, and I have ventured to include a few notes on this phase of the subject.

The Northern Limit of Distribution of Certain Prairie Species.

Many species of dry open areas, generally of southern distribution, reach their northern limit in or near the Illinois River sand regions. This northern distribution is discontinuous, there being a considerable interval south and west of the sand regions in which these species are not represented. Morse (1899:316) comments on this feature of distribution as follows:- "Species belonging to a southern zone and adapted to a sandy soil may find their northern limit considerably higher up, both latitudinally and vertically, than other species equally characteristic of the same zone, but restricted to a damp and heavy soil."

Hart (1907:203) cited the presence of Melanoplus impudicus and Eritettix virgatus in the sand region as illustrative of Morse's suggestion. I have found that a large quota of the sand-prairie fauna shows exactly this relation.

It is a well known principle of plant ecology that edaphic extensions of adverse types (xerophytic or hydrophytic, for instance) are always more widespread than those of favorable type. This principle is merely an application of the general law of ecological competition. Those species of a particular province or zone, which are character-

istic of damp and heavy soils (these are more favorable to general life conditions) are not prevented from spreading to other provinces because their distinctive habitats are not represented, but because the competition with the species climatically adapted to these habitats does not allow invasion. The southern or southwestern forms are adapted to arid conditions. The Illinois climate and typical Illinois soils favor species adapted to humid conditions. The Illinois sand areas present arid conditions - about as arid in sand in Illinois as would be the case in heavier soils in the southwest. The Illinois sand areas therefore approximate southwestern conditions in general more closely than they approach the more arid (upland) conditions of the eastern humid region. The edaphic extensions of the southwestern fauna thus find their outermost distribution in the sand areas of the humid districts, not only because the physical environment is suitable, but because the competition of the species of the humid fauna is negligible.

Distribution of Sand Beetles.

Sand regions occur locally over practically all of this country, and as the physical conditions are similar in all of these areas, a considerable number of the plant and animal species of the sand associations are common to several or many of the localities. This common element of sand areas consists for the greater part of species that are especially adapted to the sand environment, and which usually are found nowhere else. These species thus have very extensive though discontinuous ranges.

For purposes of comparison with the sand region of the Illinois river valley, beetle lists from other sand areas were consulted, and certain distinctive sand species of the Illinois region were listed

in the table on page 77 for each sand area in which they occurred. The lists are by no means complete and the absence of a record does not mean that the species is necessarily absent. The results show:

1. That the sand associations are to be classed with the arid formation of the prairie - they are Upper Sonoran.
2. That many of the species extend as far east as the Atlantic coast. Extensive sand deposits occur along the entire coast. Doubtless many western forms have migrated along the Atlantic border north from the Gulf region.
3. That the proportion of western species in an association gradually decreases with distance north and east.
4. That the Illinois river region and the Lake Michigan region in northern Indiana have very closely related sand associations, most of the characteristic species being common to both areas.
5. Records not included in this table show a very close relationship between the Illinois river sand associations and those of both the Kansas sand-hill district of the Arkansas river, and the large area of sand-hills in central and western Nebraska, which represent the maximum development of the sand-prairie associations.

DISTRIBUTION OF SAND BEETLES.

RECORDS FROM LOCAL LISTS OF VARIOUS SAND REGIONS.

× = PRESENT
? = PROBABLY PRESENT

SPECIES / LOCALITY	SOUTHERN NEW MEXICO AND ARIZONA	NORTHERN NEW MEXICO AND ARIZONA	KANSAS DUNES OF THE ARKANSAS RIVER	GRAND TOWER, ILLINOIS - SAND BEACH OF THE MISSISSIPPI RIVER	SAND AREAS OF THE ILLINOIS AND MISSISSIPPI RIVERS	SAND AREAS OF LAKE MICHIGAN - WAUKEGAN - - NORTHERN INDIANA -	SAND ARES OF INTERIOR INDIANA	SOUTHERN SHORE OF LAKE SUPERIOR	SAND REGIONS NEAR WASHINGTON, D.C.	SAND AREAS AND COAST OF NEW JERSEY
Cicindela formosa generosa			×		×	×	×			×
Cicindela scutellaris lecontei			×	×	×	×	?			
Cicindela lepida				×	×	×				×
Geopinus incrassatus			×	?	×	×	×	×	×	×
Anisodactylus rusticus				?	×	×	×	×	×	×
Harpalus herbivagus	×	?	×		×	×	×			×
Harpalus erraticus					×	×	×		×	×
Harpalus testaceus			?		×	?	×			
Nothopus zabroides		×	×		×	×				
Hister biplagiatus				?	×	?	×	?	×	×
Saprinus pennsylvanicus		×			×	×	×	×	×	×
Lacon rectangularis		?	×	?	×	×	×			
Cardiophorus cardisce		?	×	?	×	×	?		×	×
Acmaeodera spp.					×	×	×			×
Canthon vigilans					×	×			×	×
Canthon nigricornis					×					
Geotrupes opacus					×	×	×			
Lachnosterna prunina					×	×	×			
Polyphylla hammondi		×	?		×					
Trox scabrosus					×	×				×
Plectrodera scalator		?	?	×	×	×				
Batyle suturalis				?	×	×	×			×
Dectes spinosus				?	×	×	×		×	×
Mecas pergrata				?	×		×			
Tetraopes femoratus				?	×	×	×			
Metachroma angustulum					×	×	×			
Metachroma parallelum					×	×	×			
Chrysomela auripennis		?	?		×					
Blepharida rhois		×	?		×	×	×		×	×
Opatrinus notus					×		×		×	

VII. ECOLOGICALLY ANNOTATED LIST OF SPECIES

GASTROPODA

The acid soil of the sand-regions, its paucity of calcium carbonate, and other adverse conditions, exclude practically all snail life from the sand-prairie. No snails at all were seen during the summer, and in the spring three empty and worn shells were found. Two of these were aquatic species and the third was a an inhabitant of deep forest so that they were all utterly foreign to sand-prairie. The species were: *Planorbis trivolvus* Say, from a sandy lane at the Devil's Hole; *Campeloma integrum* De Kay from a sandy roadside east of Havana; and *Pyramidula solitaria* Say, from a blowout at the Devil's Neck.

Order OLIGOCHAETA

Diplocardia sp. (indeterminable). April 4.

One specimen taken under a board with *Lithobius* and *Lacon rectangularis*, in bunch-grass. Earth-worms eat the organic part of the soil; as sand has a very small humus content, the earthworms are very rare in sand. The decay of the boards or logs may furnish more of the humus than the sand. Another earthworm, probably the same species, was taken in a similar situation on another dune.

Order CHILOPODA

Lithobius sp. (indeterminable). April 4, 5.

One specimen taken under a large board near a dune summit. The soil had quite a little humus, indicating rather an advanced stage of bunchgrass. Another from under a log at the

edge of a field. Myriapods are very rare in the sand-prairie; the soil conditions are unfavorable. The genus is predaceous.

Order DIPLOPODA

Parajulus sp. (indeterminable). April 6.

Several specimens in a non-typical part of the Devil's Hole bunch-grass. Considerable humus was in the soil. The scarcity of organic material in the sand normally keeps millepeds out of the sand region.

Order ACARINA

Trombidium locustarum Riley July 19.

This small red mite is a very common parasite of grasshoppers. Several specimens were taken on grasshoppers from blowsand at the Devil's Hole.

Order ARANEINA

Xysticus gulosus. Keyserl. April 1, 4.

A common brown crab-spider, taken hibernating in mullein along the border of a field, and also under a board in bunch-grass southeast of Havana. A widely distributed species.

The Thomisidae are usually found in flowers, where they lie in wait for insect food.

Drassus sp. (indeterminable). April 4.

The Drassidae are common spiders which roam about in search of insect prey. They do not spin webs and are inclined to be of nocturnal habit. One immature specimen, taken under a board in bunch-grass.

Steatoda corollata Em. April 1, 4.

A common and widely distributed species of the family Theridiidae. These are usually small spiders and build irregular beds. Found hibernating under boards in the bunch-grass, and along the border of a field, Very young specimens.

Euryopis funebris Em. April 1.

A common and widely distributed species. Young specimen taken in sheltered place at the border of a cultivated field.

Epeira stellata. Walck October 8.

A small specimen, taken in the blow-sand of the Devil's Hole. The orb-weavers, or *Epeiridae*, build large spiral webs in herbaceous growth, and entrap insect prey by this means.

Lycosa fatifera. Hentz. June 28, October 8, April 8.

This species is a large *Lycosid*, and is found in many associations of the sand-prairie. A female was dug from a burrow in June, a male at the edge of a blowout in October, and a number of females in April were dug from burrows. All of these are from the Devil's Hole. The males are found only in the fall or late summer; the females hibernate in their burrows and lay eggs in spring. The egg-case is carried about attached to the female. The burrows are vertical, usually about one-half inch in diameter; they are usually capped by a small turret, especially when the burrow is in bunch-grass. At about halfway down the burrow enlarges into a fusiform chamber. Some of the burrows reached a depth of twenty inches. Beetle remains were sometimes found in these chambers.

This species has been confused with *L. arenicola* and *L. domifex*. Emerton determined the specimens as *L. missouriensis*; this in Chamberlin's revision of the genus is synonymous with *L. fatifera*. It is quite abundant in the Devil's Hole and is one of the dominant species. It is known from Alabama, Georgia, Texas, Missouri, Kansas, Illinois (also in the Lake Michigan region) and Utah.

A freshly excavated burrow of a Lycosid is shown in Figure 21, p.178.

Lycosa erratica Hentz. April 8, 9.

A common and widely distributed species. It is conspicuously marked with gray and black. Found running about in bunch-grass. It is of a roving habit; one specimen, however, was found in the burrow of another Lycosid, probably to molt, as a recently cast skin was found near the top of the burrow.

Lycosa sp. (indeterminable). October 8.

An immature specimen, taken near the edge of a blowout at the Devil's Hole.

Geolycosa sp. (indeterminable). April 7.

One specimen, resembling Lycosa fatifera, dug from burrow in bunch-grass dune north of the Devil's neck.

Attidae sp. (undeterminable). October 8.

Taken on plants at the Devil's Hole. The jumping spiders run jerkily and jump to and fro on the stems and leaves of plants, in search of insect food. One Phidippus taken along the roadside was eating a fly, perhaps Lucilia caesar. They are very common spiders.

Phidippus insolens? Hentz. April 4.

One specimen, found dead inside a silken case under a cactus lobe, bunch-grass dune near Havana. Hart records the species as very common in blowsand and on dune summits. Resembles female mutillidae.

Phidippus audax Hentz. April 4.

A black species with orange spots; quite common hibernating under cactus lobes on a dune summit.

Phidippus ardens Peckham. June 28.

A male jumping spider, taken running about on the bare sand in the bunch-grass association.

Phidippus McCookii Peckham. October 8.

A jumping spider with red abdomen, taken in a blowout, close to the Cassia growth. The specimen is a male.

Order COLLEMBOLA

Entomobrya sp. April 1.

Found under logs in sand with considerable humus content. Another collembolan was found in pure or almost pure sand, but no specimens were captured.

Order PLATYPTERA

Termes flavipes Kollar. July 25, April 1, 4.

The termites are very abundant in sand regions, where they are found under boards. They eat wood tissue, and logs in the woods are often found with most of the interior eaten out. Several colonies containing workers, soldiers, and winged forms were found in April. They are common in the Lake Michigan sand region and on the dry soils of Southern Illinois. Widely distributed.

Order EPHEMERIDA

Hexagenia bilineata Say. July 6.

A dark colored may-fly of large size--wings clouded and dark in color. This is the most abundant may-fly in the river--"willow--bugs"--the residents call them as the full-grown nymphs crawl up on the trunks of the willows of the flooded bottoms to cast off the pupal skin and emerge as adults. The tree trunks are often covered with these exuviae. The adults fly actively about at night; their numbers are so great that the heaps of dead willow-bugs accumulated under the arc lights have had to be hauled away in wagonloads. Several species of Ephemeridae are very numerous

in early summer at the Devil's Hole; they probably form an appreciable element in the food supply of predaceous insects.

Hexagenia variabilis Say. June 25.

A rather large may-fly with yellow wings. Very common throughout the sand-region in the breeding season. The larvae are very numerous in the river. The adults are found as far as three miles from the river.

Order NEUROPTERA

Chrysopa oculata Say. August.

The "lace-winged fly", a common and widely distributed species. The larvae are known as "aphis lions", and roam about on plants in search of plant-lice, from which the juices are extracted by means of the mandibles. The eggs are laid on long stalks. No specimens were taken, though several were seen. Hart took it at the Devil's Hole.

Cryptoleon signatum Hag. June to August.

This species was seen, but no specimens were captured. Hart found it very common in different parts of the sand regions. No other Illinois records.

The larvae of the Myrmeleonidae dig pits in loose soil and lie in wait at the bottom for insects to fall into the trap. These pits are common in sand, wherever there is protection from wind.

Two other Myrmeleonids taken by Hart were not formerly

recorded from Illinois. These are *Brachynemuris irregularis* Currie and *Myrmeleon immaculatus occidentalis* Currie. The family reaches its highest development in the southwest.

Order ODONATA

Ischnura verticalis Say. July 8.

One specimen, taken at the Devil's Neck in bunch-grass. As far from the river as some of the bunch-grass areas , the dragonflies are very abundant. They form a derived element in the association. Being predaceous, they exert a considerable influence upon the insects life of the sand-prairie, although they are not typical members of the association.

Epicordulia princeps Hag. July, August.

This dragonfly is the most abundant species of early summer in the river district. It is very commonly seen at the Devil's Hole, and is an important predaceous species of the bunch-grass.

Sympetrum rubicundulum Say. July 3.

This dragonfly is not very common. One specimen was taken in the bunch-grass pasture at the Devil's Hole.

Perithemis domitia Drury. June 28.

Rather a common species, taken at the Devil's Hole, in the bunch-grass.

Order ORTHOPTERA

Ischnoptera sp. (indeterminable). April 4.

In decaying log at the edge of the bunch-grass association. Probably inaequalis Sauss--Zehnt. All were nymphs. This is a forest species; none of the Blattidae are typical sand-prairie forms.

Family ACRIDIIDAE

The Acridiidae, or locusts, are the dominant group of the Orthoptera. They hatch usually in spring and mature in summer, reaching their maximum development late in summer. The food is almost entirely vegetable, principally grasses. Some of the locusts are migratory. Those living in open plains usually have better powers of flight than the locusts of thickets or forests. The Acridiidae are diurnal, non-social; they do not build nests or dig holes, they are short-lived; they usually possess no special adaptations; they are active only in the most favorable season; we may thus say that their habits are very simple; they have taken the simplest means to solve the problem of existence. The locusts are best developed in warm climates--in North America they are commonest in the southern and southwestern parts, and in the prairie region. They are very sensitive to local environmental differences, so that the species are good indices in local distribution studies. Geophilous species are more suited to unfavorable environments. The Acridiidae have very many enemies,

mites, predaceous beetles, flies and wasps, birds, reptiles and mammals. They are one of the important sources of animal food supply.

Tettix ornatus Say. April 8.

A member of the sub-family Tettiginae or grouse locusts. The food is mainly vegetable. Most of the grouse locusts are of northerly distribution. Found at the bottom of a hollow in the bunch-grass. Geophilous. The peculiar life history of the grouse locusts (they hibernate as adults) may possibly be an adaptation to conditions in the north, where the growing season is shorter. It may also serve as a device for avoiding competition with the more dominant locusts, which are most active later in the season. This species is not typical of bunch-grass.

Tettix hancocki Morse. April 4, 8.

Found in the bunch-grass, and with the preceding species. Much more abundant in the sand-prairie, though still not a typical species. Of northerly distribution.

Mermiria bivittata Serv. July 6, 19, October 8.

Like the other members of the sub-family Tryxalinae, this species is phytophilous and flies strongly. Found in the Devil's Hole usually in the longest and driest grass. It is probably never found in bare sand. A typical bunch-grass species, of western distribution.

Mermiria neomexicana Thom. July 29.

Habits and local distribution similar to those of the

preceding species. It is more restricted to the western regions, is smaller, and not so commonly found in the Illinois sand regions. Hart's record is the first for Illinois.

Syrbula admirabilis Uhl.

This species is quite common in the drier parts of Illinois, and was not taken at Havana probably for the reason that it is abundant at a time of year when no collecting was done. Mr. Hart found it in the sand regions in the middle of August.

Eritettix sp. (undescribed). April 1, 8.

Thought by Mr. Hart to be a new species. (Cf. Hart and Gleason, 1907:231, 259). Nymphs common in bunch-grass at the Devil's Hole in spring. The eggs probably hatch very early in the season, as those found were too small to have wintered as nymphs.

Ageneotettix deorum Scudder. July 19, October 8.

Taken as early as July 6. The habits are more like those of the Acridinae. as it depends less upon its wings and more upon its power of leaping. It has also a geophilous tendency. It is a western species occurring east only as far as the Lake Michigan sand region. It is a common bunch-grass species.

Amphitornus bicolor Thom. July 8.

Taken at the Devil's Neck on a high grassy dune. A very active species. This is one of the most typical plains species, and has formerly been found only from the western states, Montana

to Texas.

Arphia sulphurea Fab. June 6, 7, 9, 23.

One of the Oedopodinae, which are geophilous. A common and widely distributed species, rare in sand-prairie, however. The winter is passed in the nymph stage. The adult state is reached as early as May 1 according to Blatchley, and the species remains active till about the middle of July, when it is replaced by Arphia xanthoptera.

Arphia xanthoptera Germ. July 25, October 8.

Taken at border of forest at Matanzas Lake, and at the Devil's Hole in bunch-grass.

This species is similar to A. sulphurea, its close relative, in habits and distribution. It is however, larger and of stronger flight. The chief difference is in time of appearance, and there seems to be a mutual adaptation in this respect. Sulphurea winters in the nymph stage; xanthoptera does not become adult till the other species is nearly gone. There is thus no competition between the two species, which otherwise would probably be keen rivals. Certain other species show very similar seasonal distribution, and it is thought that this may be explained in terms of avoidance of competition.

Neither of the two species is typical of bunch-grass or sand-prairie.

One specimen of xanthoptera had evidently run into a plant of Opuntia, for a number of the spines and thorns were stuck

in the joints of the legs and in the neck joint.

Chortophaga viridifasciata De Geer. April 1.

The winter in this species is passed in the nymph stage. The locust is mature from April 15 till November 1, according to Blatchley. It is the first locust to reach maturity in the spring.

It is an unusual species; it is very widely distributed geographically, and thrives in a great variety of habitats. It has no close relative. There must be some peculiarity about the species to account for its wide geographic, local and seasonal distribution.

Two nymphs were taken in the bunch-grass, but it is not typical of sand-prairie.

Hippiscus phaenicopterus Germ. July 5, 19.

Common in bunch-grass. Winters in the nymph stage. It matures probably late in May. There is a time adaptation with species of *Hippiscus*, much as in *Arphia*. *H. tuberculatus* is the earliest, followed by *phaenicopterus* and *haldemanii*, which in turn give place to *rugosus*. The data are too scanty, however, to allow important conclusions, and these would be of no particular significence in this discussion, as *tuberculatus* is only accidental in the sand regions, and *rugosus* is by no means common.

Phaenicopterus is a dry grassland species of southern distribution; it is not a distinct sand species.

Hippiscus haldemanii Scudder. July 19.

The species winters in the nymph stage. The seasonal

relations to other species have been discussed under H. phaenicopterus. The species is probably restricted largely to sand. It is found in the bunch-grass, and not in blow-sand. Not nearly so common as phaenicopterus. It is a Great Plains species, found in the states east of the Rockies.

Hippiscus rugosus Scudder. August.

This species winters in the egg stage, appearing later in the season than the two preceding. It ranges east of the Rocky Mountains, and is probably more abundant in the eastern part of its range. Taken at the Devil's Hole in bunch-grass, by Mr. Hart.

Like many other species, rugosus is found on many kinds of dry habitats in the south, but in the northern part of its range, it is confined to isolated areas of sand.

Dissosteira carolina Linn. August.

A common species of roads, but is not found in bunch-grass or bare sand area in the Havana region. This is rather surprising for at Grand Tower, Illinois, it was regularly found on the sand-plain of the river beach. Those found on sand were conspicuously lighter in color than others found on black soil.

Spharagemon wyomingianum Thom.

A very common geophilous species of the bunch-grass. Probably the dominant member of its subfamily. It winters in the egg stage, and is mature from the middle of June probably until frost. A very widespread species, showing great geographic

variation. In the northern and eastern part of its range the species is confined to sandy localities. It is not found in blowsand or blowouts. In the eastern part of its range it probably is more important than in the plains region, because in the east it is free from the competition of other species adapted to arid conditions.

Mestobregma thomasi Caud. July 19.

A common geophilous bunch-grass species. It is a rather active species, of western distribution. A late summer form. It is common on the dry soils of southern Illinois, but toward the north becomes restricted to sand.

Psinidia fenestralis Serv. July 6, 19.

This species is restricted to sandy areas, it is an eastern species, not common west of the Mississippi. In the bunch-grass it is next to Spharagemon in abundance among the Oedopodinae. It occurs rarely if at all in blowsand. In the Havana region it is much more abundant than it would be in similar associations farther west.

Trimerotropis citrina Scudder. July 8.

This species is most commonly found on the sandy shores of large rivers, and on the shores of the South Atlantic and Gulf States. It occurs also in the interior in sandy or sparsely vegetated arid places. One specimen from the Devil's Neck, in bunch-grass, Hart took one at the Devil's Hole. Not a typical bunch-grass species.

Schistocerca alutacea Harris. July 19, October 8.

This large locust is mature from late July till frost. It occurs east of the Sierra Nevadas, and is of scattered distribution, being more common in the southern part of its range. Restricted to sand northward. In the Devil's Hole it is seldom seen far from blowsand. It seems to be marginal between the bunch-grass and bare sand areas.

Campylacantha olivacea Scudder. July 19, October 7, 8.

The species is phytophilous and short-winged. In southern Illinois it is abundant on *Ambrosia bidentata*, but in the Havana area it does not seem to be confined to any one plant. A typical western species, found towards the north and the east in sand. In the Havana area it is confined to bunch-grass.

Melanoplus flavidus Scudder. July 19, October 8.

Mature from July till frost. It is found from Illinois and Montana to Texas and Arizona (Scudder). Widespread geopraphically, but very restricted locally to sand that is almost bare--blowsand and the bare basins of blowouts. In this region it is the most characteristic locust of the bare sand .

Flavidus was very scarce in 1910, though Hart found it it abundant in former years.

Melanoplus atlanis Riley.

Not found in true bunch-grass or blow-sand. Not rare, however, in other parts of the sand region. In Southern Illinois it is the dominant locust of the lower Illinoisan glaciation. All

summer.

Melanoplus scudderi Uhl. April 4.

One dead specimen, from under log along fence, bordering bunch-grass. A late autumn locust, mature from August 5 to November 22. It is thus able to withstand quite severe frosts. As it is shortwinged it is probably sedentary in habit. It is found in borders of open woods fence-rows, and dry grassy situations. Not a typical bunch-grass species. Its range is "United States east of Great Plains." (Scudder)

Melanoplus femur - rubrum De Geer. July 23, April 4.

Common along roadsides and in cultivated fields. Totally wanting in bunch-grass or blowsand. Found only where a certain acount of humus and clay occurs in the soil. All summer. This is the commonest Melanoplus in northern Illinois prairies. In the sand-prairie it is replaced by M. angustipennis.

Melanoplus angustipennis Dodge. July 19, October 8.

This is the most abundant and most characteristic locust in the bunch-grass. Common throughout the sand region, from July until frost.

Angustipennis is a western species, and was formerly quite rare, but of late years has been increasing in numbers in the west. Its range is from Indiana to Montana and south through the plains region to Texas.

This insect is the chief plant-eater in the Illinois sand-prairie, and is probably of greater importance in the associ-

ation than any other species. It is one of the very destructive species of the genus. It is found on blowsand and in the margin of blowouts.

Melanoplus differentialis Uhl. July 25.

Common in flat sandy country and roadsides. Co-extensiv with cultivation, but very rare in the native blowsand or bunch-grass areas. Two were found in the Devil's Hole region just east of the walnut grove.

Melanoplus bivittatus femoratus Burm. July 25.

Taken in two places where the conditions indicated presence of an advanced stage of sand-prairie--the first was a pasture near Matanzas Lake, the second a small area east of the black oak woods near Quiver Station.

Scudderia texensis Sauss.-Pict. July 12, July 19.

The eggs of this katydid are inserted at the edge of leaves. The adults are active from mid-July or earlier till frost. Most of the katydids are arboreal, this species is not arboreal to any great extent. At the Devil's Hole they are found in the bunch-grass quite a distance from any trees. Phytophilous. It has been taken in blowsand, but is more typical of bunch-grass, where it is fairly common.

Ceuthophilus sp. (indeterminable). April 1.

This genus comprises wingless underground or cave crickets. The species are probably omnivorous, and are nocturnal in habit, hiding by day in the ground or under logs. A number of

species are found in the plains region; others extend over the eastern states. The one specimen taken is a nymph; others were seen during the previous summer upon digging up the burrows of mammals. The Ceuthophili are an isolated group of peculiar habits; they thus occupy an unusual place in the association. They are never abundant.

Conocephalus robustus Scudder. July 19.

This genus is more or less campestrian, the eggs are laid in grass leaves, and the adults, when resting head downward on a grass stem, closely resemble a grass leaf (Hart). The stridulation is very loud and shrill, usually occurring at twilight. The species is found in the northern states east of the Rocky Mountains (Scudder). Blatchley says that they occur only along the Atlantic coast and the shores of the Great Lakes. Lugger found it near the shores of Lake Minnetonka and White Bear Lake. The species is probably restricted to dry or sandy habitats, and is not typical of bunch-grass.

Gryllus abbreviatus Serv. April 4.

Dead specimens taken under logs in bunch-grass. This field cricket is nocturnal and omnivorous in habit, even cannibalistic, according to Blatchley. Found in open fields usually under shelter of some kind. Much more common in other regions than the sand-prairie.

Oecanthus confluens July 6.

The eggs of the tree crickets are inserted into the

stems of tall herbaceous plants, usually composites. The eggs hatch in May or June; the insects are mature usually in July. The goung Oecanthids feed upon aphids or plant lice. The insects usually stay upon the plants which they frequent. They are to a large extent nocturnal.

Order THYSANOPTERA

Anthothrips verbasci Osborn. Havana, April 1.

The common mullein thrips; it occurs regularly on Verbascum along roadsides. Not typical of sand-prairie.

Order HEMIPTERA.

Tettigidea hieroglyphica Say. July 3, 8, 12.

This small Cicada was quite common in bunch-grass at the Devil's Hole and the Devil's Neck. In former years it has been much less abundant. A large robber-fly, Proctacanthus rufus, was taken at the Devil's Neck with a Cicada in its grasp. The Cicadidae are normally forest insects, but this species is probably one of open plains. It ranges from the foot-hills and plains of the southwestern states as far east as New Jersey, where it is found in sandy pine barren regions. It has not been taken in Illinois except in sand.

Enchenopa binotata Say. June 25, July 25.

A common species, usually found on the hop tree, Ptelea trifoliata. Taken on Osage near the Devil's Hole, and on the hop tree near Matanzas Lake.

Scolops grossus Uhl. October 8.

Taken at the Devil's Hole by sweeping in bunch-grass. A common and generally distributed species of grassland, ranging from the western states to the Atlantic border. It is not abundant in the eastern part of its range.

Ormenis pruinosa Say. July 8.

Taken on Osage hedge beside a sandy road east of the Devil's Neck. A common and generally distributed species.

Agallia sanginolenta Prov. April 4.

Abundant under logs in bunch-grass pasture southeast of Havana. Common in the western states, ranging east to the Atlantic border.

Typhlocyba comes Say. April 1.

This common Jassid is known as the grape leaf-hopper. In the Urbana region it is found in early spring under logs in the woodlands. Near the Devil's Hole it was found under logs at the border of a cultivated field.

Fitchia aptera Stal (nigrovittata Stal). April 9.

Taken on southern slope in very open bunch-grass at the Devil's Hole. One specimen wingless. A typical plains species, ranging east to the Atlantic states. The only record from the Illinois sand region.

Sinea diadema Fab. June 20, July 19, October 6, 7.

A large and powerful reduviid, which preys upon a variety of insects. It is usually found in plants or flowers. Taken at the Devil's Hole in bunch-grass and in blow sand. They have been taken on Kuhnia, and on Cassia, where one was seen eating a lady bird, Coccinella 9-notata. A very widely distributed species, from the plains to the Atlantic border. Common in many habitats.

Reduviolus ferus Linn. April 8.

Probably our commonest nabid. The insects feed upon small insects, usually immature stages. Common in herbaceous growth; it is often found taking shelter under logs. A Devil's Hole specimen was taken on the sand in bunch-grass. The species occurs over practically the entire United States; it is also widely distributed in Europe.

Adelphocoris rapidus Say (Calocoris Fieber). October 8.

Found in bunch-grass sweepings with the following species, which it resembles closely in habits. Very common in black soil prairie

and in cultivated fields, but rare in sand prairie. Widely distributed.

Lygus pratensis Linn. October 6, 8, April 1.

A very common and widely distributed capsid. These insects are plant feeders exclusively. Taken at the Devil's Hole on Kuhnia and in bunch-grass sweepings. The species is very much less common in sand prairie than in cultivated fields and in black-soil prairie.

Poecilocapsis lineatus Fab. June 20.

Taken in cultivated field on plants. Habits similar to those of Adelphocoris and Lygus; the species is not so common, however.

Phymata fasciata Gray (wolfii Stal). July 23, 29.

The common "ambush bug"; frequently found in flowers, lying in wait for insect prey, which is seized and held by the powerfully developed front legs. An insect primarily of open places and forest margins. Taken on Pycnanthemum at the edge of woods near Matanzas Lake. One specimen from the Devil's Hole, on Cacalia. Rare in sand prairie. This species is of eastern distribution; other species in the western states are more typical of prairie.

Piesma cinerea Say. June 24.

A small tingitid species, quite common and widely distributed; taken in herbaceous growth along a sandy roadside.

Lygaeus bicrucis Say (Melanocoryphus Stal). July 29.

A widely distributed species, occurring on Cacalia atriplicifolia, on which it is very abundant at the Devil's Hole, and throughout the sand prairie. All the Lygaeidae are plant feeders. More common in dry or sandy localities.

Lygaeus kalmii Stal. July 12, April 4, 5.

Found quite commonly on *Apocynum* with *Chrysochus auratus*, in an abondoned field at the Devil's Hole. Taken in spring under a cactus lobe in bunch grass, and under a log at the edge of a cultivated field. One of the commonest members of the family, ranging from the plains and the southwestern states to the Atlantic border. It is commonest in the east.

Oncopeltus fasciatus Dallas. July 23.

Taken on *Asclepias syriaca* at Matanzas Lake, and also in herbaceous growth on the forested marginal dune south of Havana. Ranges from the southwest to the Atlantic states, and is almost always associated with the milkweed.

Ligyrocoris diffusus Uhler (*sylvestris* Stal). October 8.

One specimen,swept from bunch-grass. A widely distributed species usually found in grassy situations. Not characteristic of sand.

Geocoris bullatus Say. April 1, 7, 9.

Species of *Geocoris* are often found crawling about on sand in sparse vegetation. Taken in bunch-grass at the Devil's Hole, and in blow sand at the Devil's Neck. Common along the Atlantic coast, and is found as far west as Colorado. A typical species of sand.

Microtoma atrata Goeze. April 5.

This black lygaeid is the single representative of the genus, and is of wide distribution. One specimen, taken under a board at the edge of a field.

Corizus sp. (undetermined). April 1.

Taken under a log at border of cultivated field. The Coreidae

eat both animal and vegetable matter, particular species probably inclining in one of the two directions. This species is probably predaceous in large part.

Alydus sp. (undetermined). July 5.

Coreids of this genus have while immature a remarkable superficial resemblance to ants. The specimens taken were all immature. They were found in the Cassia belt of blow sand and in a small blow-out, and in bunch-grass. Hart records three species of Alydus: pilosulus H.-Schf., conspersus Mont., and eurinus Say. The genus is found usually on dry or sandy ground, in sparse vegetation, and ranges from the plains to the Atlantic region. A. pluto and A. setosus are confined to the western states. Probably a predaceous species.

Stachyocnemis apicalis Dallas. July 5, October 6, 8.

Common in the basin of small blow-outs and in the Cassia growth in blow-sand, all summer. One of the few characteristic basin animals. It is probably always found in sand, and has a very wide range California to Florida and from the Great Plains to the northern Atlantic states. The only species of the genus in North America at least. Its wide range is due probably to freedom from competition; no other species is closely related to it either taxonomically or in habits, and in its open habitat few other species are there to compete with it. There is no direct evidence as regards the nature of the food, but the species is probably predaceous.

Chariesterus antennator Fab. August 12, 15.

Taken by Hart quite abundantly, usually on Euphorbia corollata. Occurs from the southwestern states and the plains region to the At-

lantic border.

Cosmopepla carnifex Fab. June 24.

The food of Pentatomidae is both animal and vegetable. *Cosmopepla* is probably a plant feeder. On *Scrophularia* in the black-jack woods and on other plants along roadsides. Near Urbana a number of the insects were taken on *Linaria linaria* (toadflax), a ruderal plant. A common and generally distributed species.

Euschistus variolarius Beauv. October 8, April.

One of the commonest and most generally distributed pentatomids. Found in bunch-grass on *Kuhnia* in the fall, under boards in spring. Devil's Hole and Devil's Neck. It is a plant feeder.

Hymenarcys nervosa Say. April 4.

Taken in bunch-grass on a dune southeast of Havana, under a board. Probably a predaceous species. Ranges from the plains region to the Atlantic border. A species of open areas and forest margins.

Pentatoma persimilis Horvath (*juniperina* Van Duzee). Oct. 8, Apr.1,4,9.

This is the characteristic pentatomid of the sand in Illinois. Its distribution is principally northern and in the Lake Michigan sand regions it is associated with the dwarf cedar (*Juniperina sabina*), a northern plant. It has been recorded from two localities in Colorado, however, and other species of the same genus are found in the west and southwest, so that the genus is typically of western distribution. It is a plant feeder, and is associated most closely with *Opuntia Rafinesquii*. Hart says it punctures the tip of the fruit. It is also found on *Chrysopsis*, *Kuhnia*, *Ambrosia psilostachya*, *Lespedeza capitata*, and grasses. The winter is passed in sheltered

places. It April it has been taken crawling about on sand, and also under cactus lobes and boards. It is a typical bunch-grass species.

Peribalus limbolarius Stal. October 7, April 1, 4.

One of our commonest and most generally distributed pentatomids. It is a plant eater. Found on Kuhnia in the bunch-grass, and under logs and cactus lobes in April. Much less common in the sand than in open areas of different soil type.

Perillus circumcinctus Stal. July 8.

This pentatomid is found in the sand regions on Rhus canadensis illinoiensis. Hart found it very abundantly in former years, but in 1910 only one specimen was seen. John B. Smith reports it as being predaceous upon beetle larvae. The members of this sub-family feed upon Chrysomelid larvae. Blepharida rhois, usually abundant on Rhus also, has a larva which feeds on the leaves. It is therefore quite probable that Perillus preys upon the larvae of Blepharida. The fact that Blepharida was also rare in 1910 (none being seen) would seem to confirm this inference. Perillus has a very wide range, Nebraska, Missouri, Canada, Dakota, New England, Panama, and the island of Trinidad (Uhler). Other species of the genus are found in the southwest and in Mexico.

Cydnus obliquus Uhl. April 8.

This insect and others of the same family are commonly found in sand or mud banks. The legs are formed for digging. The species ranges from the Rocky Mountains to the Atlantic coast. Two specimens taken crawling on the sand in open bunch-grass at the Devil's Hole. Hart took one specimen at the Devil's Neck.

Sehirus cinctus Beauv. April 8.

This genus is represented by a single widely distributed species. One specimen was taken crawling about on the sand. The cydnids hibernate as adults, probably burrowing in the sand. Hart took one specimen at the Devil's Hole on *Monarda punctata*.

Thyreocoris ciliata Uhler (*Corimelaena* White). June 25, October 8.

A western "negro bug". Very abundant on *Cassia* in blow-sand, and about the roots of blow-sand plants. Found on interstial plants in the bunch-grass. At times they were fairly swarming on the *Cassia*. One of the distinctive blow-sand animals. Not found in Illinois except in sand regions. The corresponding member of the black-soil prairie association is *T. pulicaria* Germ.

Thyreocoris nigra Dallas. April 8.

This larger species is rare in the sand region, being more typical in black-soil prairie and cultivated fields, where, however, it is not so common as *T. pulicaria*. Only one specimen was found, in addition to a nymph taken the July before, of doubtful determination. Found crawling about on sand in the bunch-grass. Corimelaenidae pass the winter in the adult stage. The range of this species is northern.

Order COLEOPTERA.

Family CICINDELIDAE.
Tiger Beetles.

The family Cicindelidae, the first family, taxonomically, in the Coleoptera, consists of a large number of predatory beetles which are surprisingly quick in their movements, both in running and flying. By far the greater belong to the genus Cicindela. These are really beautiful beetles, with metallic colors and variable elytral patterns. Aside from size and color, the Cicindelas vary hardly at all in general appearance. The mandibles are large and powerful.

The eggs are laid in small vertical holes in the soil. The females of each species select definite types of soil, with regard to slope, moisture, amount of humus, etc. The larvae, which generally do not leave the spot where the egg was laid, enlarge their burrows as they grow. They pass through three stages, hibernating in the last, become active again the following spring, pupate in summer; the adults emerge in the fall, hibernate and come out the second spring, become sexually mature late in spring or early in summer, lay eggs and die (Shelford, 1908). The life history varies to some extent with the different species, but with most two years is required for the complete cycle. One or two species require only a year. In Cicindela purpurea about 50 eggs are laid.

The food of the larvae consists of myriapods, spiders, insects, adult or larvae, of all kinds-- any small animals that come within reach. The larvae can live without food for over two weeks. The adults run and fly swiftly, being able to catch the swiftest of insects.

The larvae lie in wait for their prey, with head concealing the mouth of the burrow. They catch insects that are very large in pro-

portion to their own size, the dorsal hook helping to prevent the larvae being dragged from the burrow. When conditions are unfavorable (moisture relations or temperature often varying) the larvae of several species migrate. Most of the species dig their burrows deeper. If matters do not improve they die. The majority never get beyond the larval stage. The adults, when disturbed, run rapidly away, stopping suddenly. If pressed, they take wing, flying low and stopping suddenly as before. It takes a trained eye to follow their movements. The adults are geophilous, always being found on bare ground. They take shelter during the night in holes dug in the sand, under bark, stones, etc.

The western and southwestern part of North America present optimum conditions for the development of the Cicindelidae, and there they are most abundant and varied, though many species are widely distributed. The tiger beetles are also well represented on other continents.

The peculiar preference of the females for certain kinds of soil for egg-laying result in rigid habitat restrictions. The most common habitats are sandy roads and fields, shores of rivers, lakes, and the ocean; mud flats, and bare rock or clay exposures. The beetles are found in habitats usually occurring only locally; hence their geographic distribution, though extensive, is discontinuous.

Bombyliid flies parasitize the larvae of certain species. A few birds may be rapid enough to capture these beetles, and the lizard Cnemidophorus sexlineatus is reported to catch and eat them. The larvae being stationary are much more subject to attack, and many kinds of predaceous animals probably eat them. It is probable that physical conditions are the greatest natural check, rather than predaceous

or parasitic animals.

The Cicindelidae are dominant forms among insects; they are characteristic of open formations, usually where the ecological influence of vegetation is subordinate to physical conditions of the environment. In the sand-prairie three species represent the group, four others occassionally being present; physical conditions of the sand prairie are nearly the optimum for tiger beetle development; they thus are much more characteristic of this formation and form a more important part of it, than of more luxurious formations, as the black-soil prairie or the deciduous forest. In the sand-prairie the Cicindelidae are probably more important than the Carabidae, by which they are overwhelmingly subordinated in black-soil prairie.

Cicindela _formosa_ _generosa_ Dej. June 25, July 12,16,22, October 6.

This large species lays eggs in May and June. The generation lasts two years as described in the generic discussion.

The burrow, vertical for most of its length, opens obliquely at the top into the side of a pit, which serves to keep the drifting sand out of the burrow proper, and also as a pitfall for small animals. It is admirably adapted to the looseness of the material. The mouth of the burrow is kept open by cementing its walls with saliva. Similar adaptations must be present in the burrows of other small sand animals; at any rate they do not often cave in, though perfectly dry at the opening.

Distribution: Kansas, Texas, Colorado, and Nebraska. The eastern extension of the plains in Illinois is not given by Leng (1902: 136).

Locally it is found in almost pure dry sand in which sparse vegetation grows. In the Devil's Hole it is perhaps equally common in

bunch-grass and blow-sand. In the bunch-grass it is probably an "interstitial" animal.

It is a dominant species, one of the most powerful insects in bunch-grass and blow-sand, and the commonest species of the genus in the Havana region. A typical member of the bunch-grass and blow-sand associations.

Cicindela duodecim-guttata Dej. April 9.

One specimen was taken from a small blow-out at the Devil's Hole. Hart took one specimen in a blowout at Moline. Larval burrows usually occur in humus or clay, so that the presence of this species in the sand is more or less unusual. It ranges over probably all of the United States east of the Rocky Mountains.

Cicindela duodecim-guttata repanda Dej. June 27, July 11.

This form is found along sandy shores of rivers and lakes. Taken at the Quiver Lake beach above Havana and at Matanzas Lake. The larval burrows are found in moist depressions in sand with a small humus content. The adults are found in dry sand, however. Hart took one specimen at Moline, in a blowout on a sand hill, and Knaus records the species from the Arkansas River dunes. It occurs in Canada and the United States, as far west as Kansas and Colorado, and northwest as far as Manitoba.

Cicindela tranquebarica Hbst. August 30, September 8.

A large species, with much narrower elytral markings than C. formosa generosa. Three species were taken by Hart at Moline and Meredosia, in the sand. Knaus records C. tranquebarica (C. vulgaris Say) from the sand dunes of the Arkansas River in Kansas. It probably occurs occassionally in the sand dunes of the Havana area; the larval

burrows occur in moist sand which has a little humus intermixed. The distribution is given as "All eastern Canada and United States, in the western states as far south as Kansas and California." (Leng, 1902: 144.)

Cicindela scutellaris lecontei Hald. June 28, October 6, April 9.

The food, habits, and life history of this species are similar to those of other species. The geographic range is: Western Canada (Hamilton), Indiana, Illinois, Wisconsin, Iowa, Kansas, Nebraska (Leng). The species is usually found in sandy soil which has a little more humus than is necessary for C. formosa generosa. Most of the soil in the sand dunes of the Illinois river region has only a very small humus content; generosa is thus the commonest tiger beetle of the region. In the lake Michigan sand area more humus is present, consequently scutellaris lecontei is the most abundant species. The species may be said to be an index of the climax stage of the bunch-grass association.

Cicindela cuprascens Lec. July 11.

An elongate, green-bronzed species taken only on the wet sandy margins of rivers and lakes. Taken at Matanzas Lake, at Grand Tower, Waukegan, and the Indiana lake sand regions. It occurs in Kentucky, Kansas, Missouri, Arkansas, Texas, Nebraska, and Dakota, on the banks of rivers and on sand-bars.

Cicindela sexguttata Fabr. July 9.

One specimen was taken in the mixed forest of the marginal river dune. The species is found only in a rather advanced stage in the ordinary development of the deciduous forest, marked by an accumulation of leaf mold, in which the eggs are laid. Advanced stages of the

forest are very poorly represented in the sand region; thus the present species is to be regarded as a recent member of the forest association. Its geographic distribution closely parallels that of the deciduous forest province. It occurs in Eastern United States and Canada west of the Mississippi river, in local forested areas; reported from Iowa, Dakota, and Texas (Leng, 1902: 128).

Cicindela punctulata Oliv. July 12, 29.

The larvae of this species are restricted to more or less loamy soil; the adults are frequently seen on dirt roads and paths, and quite frequently on concrete walks in towns. It sometimes gets into sandy localities; I have taken it in the sandy lane near the Devil's Hole, and Wickham has found it on dry sand in Iowa, with scutellaris lecontei and formosa generosa. Hart has taken it at the Devil's Hole and Devil's Neck, so that it is an occassional member of the bunch-grass association. Leng gives its distribution as "Canada west to Manitoba, Maine to Florida, Louisiana, Texas, Colorado, New Mexico, Arizona, Ohio, Iowa, Wisconsin, and Illinois." It is a typical plains species.

Cicindela lepida Lec. July 5.

In the Havana region, and in the Nebraska sand hills, according to Professor Bruner, it is confined to the bare bottoms of blowouts. Found also at Grand Tower and in the Lake Michigan area. It is very wary and flies strongly. Perhaps the most distinctive species of blowout basins. Leng gives the following distribution: "Atlantic coast in New York and New Jersey; plains of Kansas, Nebraska; New Mexico, Manitoba, Illinois, Iowa"-- a typical plains species.

Family CARABIDAE.
Ground Beetles.

The Carabidae are predaceous forms which invade a variety of habitats, and, generally speaking, are the dominant members of the order Coleoptera. While they are an essentially carnivorous group, many species eat mostly vegetable food. Almost all the larvae live underground, and are also predaceous.

Pasimachus elongatus Lec. June 28, April 4.

This is a subterranean species and is occasionally found under logs, stones, and rubbish, in open woods and along the borders of cultivated fields, particularly in sandy places. The elytra are grown together at the suture, indicating a complete adoption of the underground habit. In the bunch-grass one specimen was found in digging up burrows of mammals - perhaps it was there in search of larvae of scavenger insects. The elytra of one specimen was found under a log near the summit of a bunch-grass covered dune southeast of Havana.

Pterostichus lucublandus Say. April 4.

This species hibernates in the adult state. Studies by Doctor Forbes indicate plant and animal food, partly fungi, seeds, etc., and 43 per cent caterpillars and other insects. It is found usually under logs, stones,and leaves; in the bunch grass association, it was taken under a log along a fence.

Amara cupreolata Putz. April 7.

This small, metallic beetle is one of the Carabidae which feeds largely upon vegetable matter, usually the seeds of grasses and other plants. It is found usually under logs or stones, and occurs in a

wide range of habitats. One specimen was picked up on blow-sand at the Devil's Neck.

Calathus opaculus Lec. April 5.

Common in sandy soils. One damaged specimen taken along fence in sandy loam; this is the only record from the Illinois River sand regions. Two thirds of the food is animal, the rest consists of the pollen of grasses.

Geopinus incrassatus Dej. July 8, April 1, 4.

Specimens taken on April 1 had the fresh appearance of newly emerged beetles. In July these beetles were sometimes found dead on the surface of the blow sand. Like other Carabidae, Geopinus is probably predaceous, feeding upon the insects taking shelter under the boards covering the burrows.

The species lives underground, burrowing deeply in damp, sandy localities. The burrows frequently open under boards; when these are turned over the insect retreats downward within the burrow. In summer the insect is generally a few inches underground most of the time; the soil is damp there.

Restricted to sand which is quite pure, they are not found in the sandy loam of the flats in the Havana region. It is an important index species of sandy regions. It seems to be independent of the vegetation, except indirectly, as it is found under boards in large tracts of blow sand, or in the middle of blowouts.

Cratacanthus dubius Beauv. July 29.

A brown convex Carabid of moderate size, which is very common in the eastern United States. Taken under a board in blow sand. Apparently not restricted to any particular habitat.

Nothopus zabroides Lec. June 7, July 25, August 14, 18, 22, Sep.16.

This species is very characteristic of blow sand and blowouts, but none were taken during the present studies. In 1903 and 1905 it was quite common in the Devil's Neck, Devil's Hole, and other parts of the sand region, as shown by Hart's records. Knaus records it from the Arkansas River sand dunes in Kansas; Wickham records it from the northern parts of New Mexico and Arizona (Bull. Lab. Nat. Hist., Univ. of Iowa, 1896: 157). Blatchley records one specimen (Nothopus grossus Say) from Pine, Indiana, in the lake dune region, taken by Wolcott. It is a typical Upper Sonoran species, and is characteristic of sandy habitats. It is rather peculiar that this species was not seen in 1910 and 1911, as it was common before that time.

Agonoderus pallipes Fab. April 1.

One of our most common Carabids, apparently scarce in the sand, however, only one having been taken, under a board. Not a sand species.

Harpalus caliginosus Fab. June 28, April 8.

The food of this species is largely vegetable, seeds of ragweed seeming to be a favorite. It roams about in grass and stubble, taking shelter at times under boards. It seems not to be very restricted in habitat, having been taken in the walnut grove under a board, in the bunch-grass under cow chips, and being common all over the state. It is not a typical sand species.

Harpalus testaceous Lec. August 22, September 8.

Hart records this species from under boards in blowouts, at the

Devil's Neck and at Moline. It is a western species, rare in the Illinois sand region, but confined to sandy territory. Nothopus zabroides Lec., Harpalus orraticus Say, and the undescribed Harpaline carabid are in the same category, finding their eastern limit at or near the Illinois sand regions.

Selenophorus sp. (undetermined). April 1, 4.

The carabids of this genus are small shining beetles occurring for the most part in sandy or dry localities. They are never abundant.

Anisodactylus rusticus Say. June 28, April 1, 4, 5.

A dull piceous carabid, variable in size and general appearance. This may well be called the most abundant carabid of the sandy regions, being most commonly found in spring, under boards in blow sand and bunch-grass. It hibernates in the adult state; the food is largely vegetable, about 79% according to Professor Forbes. It is common in dry habitats throughout the state, but is particularly abundant in sand.

Anisodactylus discoideus Dej. Devil's Hole, April 1.

Widely distributed, but favoring sandy localities; a typical sand species. Found usually under boards, particularly in damp places. It is very abundant along moist sandy river shores. Common on the Illinois river shores at Havana and Pekin. Abundant in the sandy shores of Lake Michigan.

Anisodactylus baltimorensis Say. April 4.

A common carabid, apparently no more characteristic of sandy habitats than of others. Taken under boards in bunch-grass near the

Devil's Hole.

Harpalini, sp. (gen. and sp. undescribed). April 4, 7, 8.

About the size of Harpalus testaceous, but even paler. Thorax very similar to that of Harpalus herbivagus. A partial description is given in Hart's bulletin on the biology of the sand areas of Illinois. A single female taken at Moline, September 8, in 190 . Its systematic place is still uncertain. Hart took a number of specimens in the Havana region since his bulletin was published, and in the present studies it was found under boards and on blow sand in different parts of the sand region. Most of the specimens were dead. Others were found alive in October. The beetle probably emerges late in summer, hibernating in sheltered places and resuming activity in the spring. Those found in April were, however, dead.

Necrophorus marginatus Fab. July 5.

A member of the family Silphidae. Taken with Saprinus and Trox on the carcass of a field mouse caught in a trap two or three days previous, in the bunch grass at the Devil's Hole. A common and generally distributed species.

Silpha inaequalis Fab. April 6.

Taken on a bone in bunch grass at the Devil's Hole, with some decaying material still attached. A common and generally distributed species, gregarious; hibernates in different stages. Members of this genus are commonly found on dacaying fungi.

Tachyporus sp. (undetermined). Havana, April 1.

A very small, broad, convex species with abruptly tapering abdomen, hibernating in the adult stage under mullein leaves or in

other sheltered places.

Other Staphylinidae of small size were taken under boards in the sand, being more often found on forest margins near cultivated fields. Hart records only three Staphylinid species, none of these from typical sand-prairie. It is quite probable that some of the large carion-feeding beetles of this family are to be found in bunch grass, but as a group the staphylinids are a very inconspicuous element in the sand prairie-fauna.

Eustilbus apicalis Melsh. July 23.

A very small brown oval convex beetle, belonging to the family Phalacridae, or shining flower beetles. They live principally on flowers, the larvae living in the heads of flowers, especially those of Compositae. The winter is probably passed in the adult stage. Taken in herbage near border of woods at Matanzas Lake.

Eustilbus nitidus Melsh. April 1.

Very similar to the preceding species, but smaller. A common and generally distributed species. Taken under a log at fence border.

Megilla maculata DeG. Havana, April 1, 7.

The common red coccinellid beetle, ~~spotted~~ with black spots. They hibernate in the adult form, often being found in large numbers in sheltered spots. These are very scarce in the bunch grass in summer, and not many were found hibernating. Next to *Coccinella 9-notata* it is probably the most common species of the family in the east central states. The food of the coccinellidae consists chiefly of plant and bark lice, and in summer the beetles are found exploring

every stem of the plants.

Hippodamia parenthesis Say. July 19, April 1.

One of our most abundant lady-bird beetles, being found with Coccinella 9-notata very commonly. These two species with Megilla maculata, are the three that take most readily to cultivated crops - they are thus to a degree ruderal, and may not have been abundant in the natural state. I find that in the bunch-grass, which is very little disturbed by man, that these coccinellids are scarce, relatively. It may be that at the time of the year these studies were made, the plant lice were very rare or at least inconspicuous - consequently coccinellids would be also rare. They were more abundant in the colder weather, while hibernating. There is also the possibility that plant lice are naturally scarce in the tough grasses of the bunch-grass association, or that they are attracted to the juicier cultivated plants of the sandy loam flats. In the summer the species was not infrequent in the growth of Cassia in the blow sand of the lee slope of blowouts.

Hippodamia glacialis Fab. April 1.

Very much less frequent than the other species. It is probable that the species is to some extent typical of dry or sandy localities.

Coccinella novem-notata Herbst. July 19, April 1, 4, 5, 7.

Commonest species of the family, especially in cultivated areas. It is usually found with Hippodamia parenthesis. In the bunch-grass it was common on the Cassia growth on lee slopes of blowouts. One was seen being eaten by a reduviid, Zelus socius. Much more abundantly found in spring, hibernating under boards or between lobes of cactus.

Adalia bipunctata Linn. July 26.

Taken in street of Havana - escaped. The species is not common in this state, having been introduced by commerce. It is increasing in numbers, apparently.

Chilocorus bivulneralis Muls. June 25.

Hibernates in the adult stage. Not an abundant species. Taken on grass plant at the Devil's Hole.

Languria bicolor Fab. June 28, July 29.

An elongate shining beetle of the family Erotylidae. Occurs on the stems and leaves of Caccalia atriplicifolia L., in the stems of which the larvae live.

Dermestes caninus Germ. April 4.

A species of the family Dermestidae. Like all the members of its family, this beetle is scavenger. The one specimen was found under a log, hibernating in the bunch-grass.

Dermestes vulpinus Fab. April 5.

Very similar in size and appearance to the preceding species. Taken under log, hibernating. Only one record.

Hister biplagiatus Lec. June 28, April 1, 4, 7, 8.

The Histeridae are small convex beetles, with truncate and striated elytra. This species is one of the larger forms, and is black with a large curved red patch on each elytron. The adults hibernate during the winter in sheltered places, or underground. Histeridae, from the surroundings in which they were commonly found, were formerly thought to be scavengers; they are now recognized as

predaceous insects. In distribution, this species is limited to sandy soil. Blatchley records an Indiana specimen which was dug from a sand bank. In New Jersey Smith has usually found it on the beach. It is never abundant.

Saprinus pennsylvanicus Payk. July 5.

Common in sandy regions, especially on beaches and shores; found in numbers on carrion. Those from the Devil's Hole were taken with Trox and Necrophorus on the body of a field mouse, trapped two or three days previous.

Saprinus sp. (undetermined). July 29.

A black species of moderate size, taken under a board at the Devil's Hole.

Histeridae, especially those of this genus, are very characteristic of sandy shores, where they are often found in remarkable abundance. A number of species are found on the banks of the Illinois river, and the Lake Michigan sand beach also shows an unusual development. About half the species listed by Blatchley for Indiana have been taken in the Lake Michigan region; many of the others being taken from sandy localities in the interior of the state.

Melanophthalma distinguenda Com. April 5.

A small scavenger beetle of the family Lathridiidae. Common under bark and logs; hibernates in the adult state. In summer the beetles are taken in flowers, particularly those of the black haw, Viburnum prunifolium. Taken under a log southeast of Havana, near border of black-jack woods.

Lacon rectangularis Say. June 25, April 1, 4, 5.

This broad, dark colored Elaterid is one of the most characteristic sand insects, being restricted to sandy soil. Found abundantly under boards and in sheltered places, in all parts of the sand dune regions. They hibernate in the adult stage.

The click beetles are so called from the peculiar habit of springing up into the air when placed upon their backs, effected by a sudden movement of the joint between the meso- and meta- sterna.

Alaus oculatus Linn. July 25.

The larva of this was found in the Quercus velutina forest; it was kept alive and the adult emerged a few months later. It is a forest species, not restricted to sand.

Cardiophorus cardisco Say. April 7.

A sand insect, being commonly found under boards or other shelter. I have one specimen from the Lake Michigan sand region (April 14, 1910). One specimen was taken from under a board at the Devil's Neck, another was found under a piece of tin; on turning the tin over an ant-nest was disclosed - the beetle ran out at the same time, so that it was impossible to tell whether there was any direct relations between the elaterid and the ants, which were a species of Phidole, perhaps vinelandica.

Cardiophorus cardisce, var. April 7.

Similar to the preceding, but without the four spots. Taken under a board at the Devil's Neck.

Drasterius elegans Fab. Havana, April 1, 4.

The species is not typical of sand; it has become of economic

importance, being very injurious to sprouting corn and wheat. Usually found along the borders of cultivated fields, hibernating in the adult stage. Taken under a board at the edge of a cultivated field near the Devil's Hole, and in a similar situation southeast of Havana.

Limonius quercinus Say. June 20, 24.

A small slender elaterid, commonly found on leaves of oak and hazelnut. A common forest species, not restricted to sand. Taken on herbaceous plants on the road to the Devil's Hole.

Corymbites pyrrhos ? Hbst. Matanzas Lake, July 23.

A large slender brown elaterid, scarce in Illinois. A forest species, not found in bunch grass. Found on a bog plant north of the head of Matanzas Lake, in bottomland forest. Blatchley records it as scarce in Indiana, in Lake, Starke, and Steuben Counties, where it was probably taken in the bogs. The record from the bog in the Havana region is of interest because the genus is of northern distribution. The plants in the bogs are also northern plants; the association is a typically northern one, and is of significance in the history of the region.

Adelocera aurorata Lec. June 20.

A dark colored elaterid of medium size, found in the mixed forest of the river dunes. Not restricted to sand and probably not found in open country. Rather scarce in Illinois. Taken on an herbaceous plant in the mixed forest.

Acmaeodera pulchella Hbst. July 5.

A prettily marked Buprestid, belonging to a large genus repre-

sentative of the southwestern and Pacific states. This genus is a departure from typical buprestids, which are normally borers in forest trees. Found on flowers of *Chrysopsis* along railroad track; occurs on many flowers, especially those of *Ceanothus americanus* L. Probably in this region a typical, though infrequent, member of the bunch-grass association.

Acmaeodera tubulus Fab. June 23.

Hart found adults of this species in flowers of *Opuntia* and *Chrysopsis*. It is recorded from other parts of Illinois and Blatchley mentions it as common throughout Indiana. A species of dry prairie regions.

Calopteron reticulatum Fab. October 6, April 4.

The elytra of this Lampyrid are soft and broadened out, so that the insect has a certain superficial resemblance to a moth. The elytra are broadly banded with black and yellow. The fireflies of the whole subfamily to which this species belongs are diurnal, and are found usually on leaves and flowers of herbaceous plants in search of insect prey. This species is also commonly found dead in spring under logs, indicating that the adults die at the approach of winter. They become adult probably about June 1. One was picked up in the blow sand beside a large area of bare sand. Others were taken under logs in bunch-grass and in blow-sand, indicating that the log habitat is self-contained, to a certain extent.

Chauliognathus pennsylvanicus De G.

A yellow soldier beetle with an elongate black spot covering the end of each elytron, except for the margin. The larvae hatch in late summer, pass the winter in a nearly full grown stage, feed ravenously

in spring, pupate, and become adult in summer. The larvae are predaceous, eating all kinds of soft-bodied insects; the adults feed upon the honey and pollen of various flowers. Chauliognathus is rare in the sand region, while very abundant in black soil prairie regions of other parts of Illinois. It is usually found on flowers, in company with the black blister beetle, Epicauta pennsylvanica.

Podabrus tomentosus Say. June 24.

Very common in other parts of the state, but rare in the sand. One specimen, taken in flowers along a sandy road side.

Trichodes nuttalli Kirby. August 13.

Specimens of this clerid were taken on Eupatorium perfoliatum in the sandy region of the lake shore at Waukegan, Illinois. Blatchley records it from Porter, Kosciusko, Elkhart, and Crawford counties in Indiana; the first three counties are largely sandy. As the Porter county specimens were taken in flowers of Opuntia, in an association similar to the Illinois river bunch-grass, it seems probable that the species is also to be found in the latter region.

Lucanus placidus Thun. June 28, July 1.

A large brown"pinching bug", so called from the large mandibles. The eggs are laid in crevices in the lower bark of trees, and the larvae feed upon wood in various stages of decay. They mature very slowly. The adult beetles remain in or beneath decaying trees or stumps by day, and emerge and fly about at night. The breeding season is June. Occasionally found dead at the base of trees, usually in the mixed forest. Placidus is more frequently found in sandy regions - its close relative, L. dama, is commoner in other parts of Illinois. Lucanus is essentially a forest insect and is

thus not a typical member of the bunch-grass association.

Canthon nigricornis Say. June 28, July 12.

A member of the scavenger division (subfamily Laparosticti) of the Scarabaeidae; smaller than others of the genus, length 6 to 9 mm. The larger members of this genus are quite commonly seen in pastures and along roads, rolling a ball of dung, which is to serve as the food of the larva. When the proper place is reached, the ball is buried in the ground and the female deposits an egg in one side of it. Comstock interprets the rolling habit as being of protection to the larvae, which would otherwise be in danger from the predaceous insects normally present in the masses of dung from which the balls are removed.

Nigricornis is never abundant; it may be restricted to sand. Blatchley records only two specimens, from Starke County, Indiana. One specimen from the Devil's Hole was taken in the burrow of a field mouse in the bunch-grass; another was taken in a bottle trap.

Canthon laevis Drury. April 1.

This is the very common tumble-bug which is common over eastern United States; it is probably not found in habitats where the soil is pure sand. One dead specimen was taken along the lane leading to the bunch-grass pasture, in sandy loam soil, under a log.

Canthon vigilans Lec. July 3.

This species, which is larger than *C. laevis*, is found from Pennsylvania and Ohio westward. It is much less common than *C. laevis*. Found in a mole tunnel in the Devil's Hole pasture.

Copris carolina Linn. July 3.

Species of the genus Copris do not transport balls of dung to any considerable distance, but bury them on or near the spot. I have dug them from burrows made in the hard clay of a street corner, under electric lights in towns. It is a very common species in pastures or along roadsides. The one specimen was found dead in the middle of an extensive bare area of blow sand at the Devil's Hole.

Onthophagus pennsylvanicus Harold. April 7.

A common and generally distributed Scarabaeid, found in carrion and excrement. Resembles a small Canthon superficially. O. hecate is the common species in other parts of Illinois; in the sand it appears that O. pennsylvanicus dominates. One specimen was found crawling about on blow-sand at the Devil's Neck; a second was taken under cow chips.

Aphodius fimetarius Linn. April 1.

This species was originally introduced from Europe, and is now widely distributed. Found commonly in or beneath half dry cow dung. Two specimens under cow chips in sandy lane near Devil's Hole.

Aphodius inquinatus Hbst. April 1, 7.

Smaller than fimetarius. Introduced from Europe, and found in same situations as A. fimetarius. Sandy lane near Devil's Hole; in spring flight and quite common at the Devil's Neck April 7.

Aphodius terminalis Say. April 4.

Quite small; scarce, perhaps typical of sandy localities. Hibernates beneath cow dung and partly buried logs. Taken under boards in blow sand with Anisodactylus rusticus and Opatrinus notus.

Geotrupes opacus Hald. April 8.

Restricted to sandy localities, occurring under cow dung in pastures, often burrowing into the ground beneath. Found dead with Harpalus caliginosus under cow chips, in bunch-grass pasture at the Devil's Hole.

Trox scabrosus Beauv. July 5.

Occurs on carrion or bones in sandy localities - scarce in Illinois. Taken with Saprinus pennsylvanicus and Necrophorus on the carcass of a field mouse.

Serica sericea Ill. June 23.

Occurs beneath shelter of various kinds; hibernates in pupal stage beneath partly buried logs. Found in the stomach of a toad, Bufo lentiginosus americanus. A number of these toads were taken in the mixed forest of the river dunes. Four stomachs contained the remains of numbers of two species of ants, several elaterids, scarabaeids, and a weevil, Phytonomus punctatus, with a few cutworms. Serica is a forest inhabiting species.

Lachnosterna prunina Lec. April 8.

One of the common May-beetles. Scarce; Blatchley found them only in Lake and Vigo Counties (sandy regions). Taken along the beach of Lake Michigan. Ranges from Ohio and Michigan to Kansas and Texas. The larvae live underground, eating the roots of grasses and other plants; the adults probably eat leaves of trees; they are nocturnal feeders. In digging up the burrow of a spider, in the bunch-grass at the Devil's Hole, quite an excavation was made; the Lachnosterna was seen crawling out of the old pupal cell into this exca-

vation, at a depth of nine or ten inches.

Lachnosterna micans Knoch. July 3, 29.

A common species of early summer. Four specimens found dead on two different occasions, on bare blow-sand, where no doubt they had been blown after death. In April, 1910, large numbers of dead insects were collected in hollows on the sandy beach of Lake Michigan in much the same way, having been blown about by the wind.

Lachnosterna implicita Horn. June 25.

A common species, one of the first to emerge in early summer. Found dead, with Lacon rectangularis, in sandy lane leading to the Devil's Hole.

Polyphylla hammondi Lec. August 12, 15, 17.

Hart found one specimen lying dead on bare blow-sand in the marginal sand ridge just north of Havana, August 17, 1903. Mr. J. D. Hood took six specimens at the Devil's Hole, August 12, 1907. They were taken at dusk, flying rapidly about four feet above ground. Three days later, Hood took seventeen males flying in the same manner, and one female was found at rest. These are the only records for Illinois. The species is of far western distribution, and is probably a typical member of the bunch-grass association of the Great Plains.

Anomala binotata Gyll. April 1.

A member of the subfamily Pleurosticti, which are leaf-feeders. Common from late spring to early summer. Not distinctive of sandy regions and more or less an insect of cultivated fields. Remains of a dead specimen, taken under a log at the border of a field.

Anomala lucicola Fab.   June 24, July 23.

A common species of early summer; occurs most commonly on the leaves of wild grape and Virginia creeper. Taken on flowers along roadside, with Strigoderma arboricola (probably breeding at that time); also on the leaves of a bog plant at Matanzas Lake.

Strigoderma arboricola Fab.   June 15, 24, July 3, 6, 11.

Common on flowers. Notes taken June 24: "The first Strigoderma was noticed a few days ago floating down the river. They are now excessively abundant on cactus, wild rose, red clover, timothy, elderberry, dew-berry, dog fennel, Verbena stricta, wild parsnip, Monarda punctata, Plantago, Saponaria, Tephrosia, Erigeron. They are most abundant on prairie plants, being quite common in the bunch-grass association and along roadsides, very few being found in the forest." July 3: "Strigoderma is still fairly abundant on different flowers." On July 6 a robber fly, Proctacanthus brevipennis, was caught with a Strigoderma in its grasp, which it was in the act of eating.

Cotalpa lanigera Linn.   June 28, July 28, April 4.

A widely distributed species; never abundant, however. An injured specimen taken on the river dune north of Havana was given to me; it may have been attracted there by the electric lights of the Chautauqua grounds. Remains of dead beetles taken under logs July 28, on the river dune south of Havana; April 4, at the border of a bunch-grass field, on a dune east of Havana.

Ligyrus gibbosus De G.   July 23, April 4.

A common and widely distributed species often attracted to electric lights. Taken in stomach of a toad with Serica sericea and

other insects. The toad was taken in the mixed forest of the river dune, indicating the same habitat for the beetle. A fresh looking specimen, perhaps recently emerged, was taken under a log in the bunch-grass.

Euphoria sepulchralis Fab. August 14, 16, 18, 30.

Common in southern Illinois; found in prairie flowers, especially Solidago. Hart took specimens at the Devil's Hole, Matanzas Lake, and other places.

Euphoria inda Linn. April 9.

Worn specimens taken at the Devil's Hole, flying about. In April, 1910, these beetles were flying about in the same way in the sand dunes of Lake Michigan, north of Waukegan, Illinois. The larvae feed upon manure or rich soil containing a large amount of humus.

Trichius piger Fab. July 11.

Found in early summer in flowers. One specimen, taken in a flower of wild rose, along sandy roadside south of the Devil's Neck. A fairly common species of general distribution.

Batyle suturalis Say. July 25.

The Cerambycidae are generally adapted to forest life. They are timber boring insects. A number of forms are somewhat aberrant, and this group is represented in prairie associations.

This species is occasionally found in flowers of Ceanthus, Cornus, and other plants. Taken on Chrysopsis villosus, near border of black oak forest three miles east of Havana. A common and generally distributed species, never very abundant, however.

Strangalia luteicornis Fab. July 5.

Occasionally found on flowers; early summer. Two specimens, taken on Chrysopsis villosus along a railroad track.

Plectrodera scalator Fab. July 8, August 13.

Associated with species of willow and poplar in sand regions. Found at the Lower end of Lake Michigan; at Grand Tower, Illinois in the Mississippi sand deposits; at Waukegan, Illinois; and at the Devil's Neck, in Populus. The larvae bore in the trees.

Dectes spinosus Say. June 28.

Frequently found in dry or sandy regions. Associated with species of ragweed (Ambrosia), on which they breed. The larvae burrow in the stems. The species ranges from New England to New Mexico and Colorado. A prairie species. Taken at the Devil's Hole.

Mecas pergrata Say. June 25, July 5.

Scarce, found also in the dry sands of southern Illinois and Indiana. This, like many other species, illustrates the principle that insects of dry regions of the south find their northern limits in sandy localities - edaphic extensions of the southern fauna; see p. . Found in low herbage of open areas. A prairie species. Devil's Hole, in mat of Chrysopsis.

Tetraopes tetraopthalmus Forst. June 6, 8, 24, July 1.

A common and widely distributed species, found on species of Asclepias. A prairie form, rare in the bunch-grass, however. The milkweeds begin to bloom in June; the adult beetlos are first seen at this time, continuing abundant throughout the early part of the summer.

Tetraopes femoratus Lec. July 25, 29, August 15, 16, September 8.

Closely resembling the preceding species, but with antennae ringed with gray at the joints. Found in drier situations than the preceding, and occurring on different species of Asclepias, usually. It is common in late summer, as indicated by the dates, part of which are from Hart's records, while T. tetraopthalmus is an early summer species. This is apparently an example of time adaptation, by means of which closely related species avoid mutual competition.

Typophorus canellus aterrimus Oliv. April 4.

This is the first species, taxonomically, in the list of sand region Chrysomelidae. This group of beetles is exclusively leaf-eating. They are represented in practically all associations, and reach their maximum development in tropical and sub-tropical regions.

A very common species, often found on foliage of wild grape. Taken from under a log in bunch-grass bordering a cultivated field.

Chrysochus auratus Fab. June 25, July 5, 12, 25.

Common and widely distributed; it lives upon the foliage of Apocynum and Asclepias. Quite common in the bunch-grass. Taken on Asclepias syriaca, Asclepias phytolaccoides, and a species of Apocynum. In an abandoned field near the Devil's Hole, which was reverting to bunch-grass, the Apocynum was very abundant over a large area, and four or five Chrysochus beetles were seen on each plant.

Graphops nebulosus Lec. April 9.

Known from Ohio, Wisconsin, Illinois, and Kansas. Taken moving about on the sand at the Devil's Hole.

Metachroma angustulum Crotch. June 28.

A western species found in this part of the country in the driest habitats, usually sand. Very abundant in the Illinois sand regions on poplar, willow, and Oenothera. One specimen from the Devil's Hole.

Metachroma parallelum Horn.

Found in abundance with the preceding species by Hart, early in June, in practically all parts of the sand region.

Calligrapha similis Rogers. April 4.

Common, more frequent in sandy localities. Hibernates under logs and rubbish. One specimen, taken under a log in bunch-grass near the Devil's Hole.

Chrysomela auripennis Say.

Hart found this species at the Devil's Neck and gives records of it from northern Illinois. Kwiat records it from sand dunes of northwestern Indiana, and Blatchley mentions it from about the prickly pear cactus in the same region. Linell gives its range as Texas to Nebraska.

Lina interrupta Fab. June 24.

Common on willow and cottonwood. Taken along sandy roadside east of Havana.

Lina scripta Fab. April 7, 1911.

Elytra usually with longitudinal black spots, sometimes wholly black. Associated with species of Populus and Salix. Taken on the ground in a poplar growth at the Devil's Neck.

Galerucella notulata Fab. July 23.

Frequent in southern Illinois, common northward in sandy localities. On herbaceous plants near forest border, Matanzas Lake.

Diabrotica 12-punctata Fab. October 6.

Normally an insect of grass-land, the larvae feeding on the roots, but now largely ruderal, occurring in numbers on cultivated plants. Much less frequent in the bunch-grass than in the cultivated regions adjoining.

Diabrotica vittata Fab. October 7.

Habits much the same as others of the genus; quite rare in the bunch-grass.

Diabrotica longicornis Say. October 6, 7.

Rare in the bunch-grass, except in fall, when a number were seen in flowers.

Blepharida rhois Forst.

Commonly found on species of sumac, upon which the larva is often seen feeding. The adult has greatly enlarged hind femora. Occurs in early summer. Very scarce in 1911.

Oedionychus gibbitarsa Say. April 4.

Commonly found hibernating in sheltered places. Occurs in summer on various flowers. Under log in bunch-grass near Devil's Hole.

Disonycha pennsylvanica Ill. April 4.

Common in moist meadows or swamp borders, hibernating under cover. In sandy regions it is associated with willow. Throughout Illinois, more frequent toward the north. Under log in bunch-grass near

Devil's Hole.

Disonycha *5-vittata* Say.

Associated with willow; from the Devil's Neck, Waukegan, Grand Tower, and the sand dunes of northwestern Indiana; all summer.

Disonycha *triangularis* Say. June 28, April 1, 4, 8.

Probably the commonest flea-beetle in the sand regions, and in other habitats throughout the state. Hibernates, being found under logs in spring. Said to be associated with *Choenopodium* and *Amaranthus*. Found under logs on the border of a cultivated field, and in the bunch-grass.

Haltica *fuscoŏena* Melsh. June 6, 8, July 22, August 12.

Not very abundant; usually found in dry or sandy regions, associated with *Oenothera* *biennis*, its food plant. Hart took it on this plant at the Devil's Hole, and at other places in the neighborhood of Havana.

Bruchus *cruentatus* Horn. July 16.

On *Cassia* *chamaecrista*, probably breeding in the seeds. An insect of the blow-sand association. Recorded from New Jersey, Georgia, Illinois, and Texas.

This species is a member of the family Bruchidae, which constitutes a small group of beetles related to the Chrysomelidae on one hand and to the Rhyncophora on the other. They eat out the inside of seeds, especially those of Leguminosae, and are known as "pea weevils".

Bruchus sp. (undetermined). April 9.

Found on the sand between tufts of bunch-grass at the Devil's Hole.

Epitragus acutus Lec. July 22, 30, August 3, 12, 14, 18, 19, 20, 22.

Found by Hart in various parts of the sand region, on flowers of Cacalia atriplicifolia. No other Illinois records. This is a species of western distribution.

The Tenebrionidae reach their highest development in the arid southwest, where they are more abundant than any other beetle family. They feed usually upon fungi, dead wood, or other vegetable substances, and may be considered as scavengers. None were seen in 1910, although they have been very common in other years.

Xylopinus saperdioides Oliv. June 25, July 25.

A common woodland species. Occurs especially under oak bark. Found under logs at the Devil's Hole and the Devil's Neck; under bark of black oak log in the forest about three miles east of Havana.

Opatrinus notus Say. April 4, 7.

Not infrequent in dry or sandy localities, under boards or other cover. A typical blow-sand species, found more commonly in bare sand than in bunch-grass. Usually associated with Lacon rectangularis.

Blapstinus interruptus Say. April 7.

Found occasionally in sandy localities under rubbish. One specimen picked up on blow sand at the Devil's Neck.

Mordella marginata ? Melsh.

The Mordellidae are small active beetles, found on flowers or dead trees. The larvae live in old wood or inside the stems of plants and are thought to be predaceous upon the phytophagous larvae of Lepidoptera and Diptera which they find there.

This is a common and generally distributed species, occurring

on Cornus, Ceanothus, and other plants. A species of clearings and forest margins.

Notoxus bifasciatus Lec. June 25, 28.

The Anthicidae are small flower beetles which resemble ants in general appearance.

This species is rather common at forest margins, usually found in flowers. Frequent in dry sand under a small clump of walnut and coffee trees; a number of lepidopterous pupae, apparently Noctuidae, in large part, were found in the same place.

Anthicus cervinus Lof. April 1.

Commonly found under rubbish in sandy places. Hibernates as imago. Taken under logs in sandy lane bordering cultivated field.

Amblyderus pallens Lec. April 7.

Found under rubbish or boards in the spring. One specimen from the Devil's Neck, picked up on the blow-sand.

Epicauta pennsylvanica DeG.

This species, which is a member of the family Meloidae or blister beetles, is found upon prairie plants along roadsides in the sandy loam flats, but is seldom found in bunch-grass or blow-sand. The larvae prey upon the eggs of grasshoppers. The adults emerge in late summer and are found upon flowers; their food is chiefly nectar and pollen. They are usually found with the soldier beetles, Chauliognathus. The whole family is best represented in the west and southwest.

Rhipiphorus octomaculatus ? Gerst. July 23.

The family Rhipiphoridae consists of wedge-shaped beetles with

short, pointed elytra. The adults occur on flowers and are comparatively uncommon. The larvae are usually parasitic, some in the nests of wasps and others on cockroaches.

This species is occasional in flowers of herbaceous plants of forest margins. I have found Rhipiphoridae very abundant in flowers of Eupatorium perfoliatum. One specimen from Matanzas Lake, on a mint, Pycnanthemum.

Phacepholis n. sp. (Chittenden). June 28.

The Rhyncophora or snout beetles form a sub-order of the Coleoptera. They are characteristically plant feeders.

This species was taken in the bunch-grass on a stem of Lithospermum gmelini. This plant has hard white seeds (nutlets); the weevil resembled the seeds so much, in appearance and position, that ordinarily it would never be distinguished from them, except at close hand.

Phytonomus punctatus Fab. June 23, April 1.

The "clover-leaf weevil", as this species is called, is a brown snout beetle, quite common and of wide distribution, its spread being doubtless hastened by cultivation. One specimen from the stomach of a toad, with Serica and Ligyrus. This one was doubtless a resident of the mixed forest, where the toad was taken. Another taken under a log near a cultivated field, having apparently hibernated during the winter.

Lixus concavus Say. April 4.

The adults breed in early summer on stalks of Rumex (dock) and other plants. The larvae probably live inside the stems. A common and generally distributed species, not restricted to sand. The

adults hibernate in sheltered places. Taken under a board at the summit of a bunch-grass dune southeast of Havana.

Lixus musculus Say. April 1.

Not a common species; taken under a log in sandy lane near the Devil's Hole.

Chalcodermis collaris Horn. April 9.

Commonly found on Oenothera in sandy places. Picked up on the sand between tufts of bunch-grass, Devil's Hole.

Centrinus picumnus Hbst. July 23, October 5.

Of general distribution; commonly found on flowers. Taken on Euphorbia corollata flowers in black oak woods near Matanzas Lake, and in the fall on flowers of a white aster along a roadside near Havana.

Barilepton filiforme Lec. April 4.

A very small black weevil, taken under a log in bunch-grass south of the Devil's Hole.

Sphenophorus scoparius Horn. April 7, 1911.

Members of this genus are known as "Bill bugs", and are often injurious to cultivated plants. One specimen was found dead on blow-sand at the Devil's Neck.

Gymnetron teter Fab. June 24.

The common and widely distributed weevil, so commonly found on mullein. Found on this plant along every roadside in the sand region.

Order LEPIDOPTERA

The Lepidoptera were, unfortunately, rather slighted in the field work, and the records are accordingly very scanty. The larvae of insects of this order eat great quantities of vegetable tissue and are among the important plant-eating groups in an association. Many of the Lepidoptera recorded by Mr. Hart were taken on roadsides, and are generally distributed. Quite a few species, however, are typical of the sand-prairie, some being found nowhere else in the state.

Danais plexippus Linn. July 5.

The milkweed butterfly was seen several times flying about in a large blow-sand area. It is more or less accidental in the sand-prairie associations.

Pyrameis cardui Linn. April 7.

Several of these butterflies were seen at the Devil's Neck, flying about over the blowsand. They are very abundant forms, are two-brooded, and visit a number of different food-plants. Hardly typical in sand-prairie.

Callosamia promethea Dru July 11.

A common large Saturniid moth. Cocoons abundant on sand-bar willow (Salix longifolia) on the sandy shore of Matanzas Lake. Not typical of sand-prairie, however.

Apantesis sp. (larvae) April 4.

The larvae of an Apantesis were taken under a log in the

bunch-grass. These larvae are very active, usually feeding upon plants of low growth.

Another Arctiid, Eubaphe aurantiaca brevicornis Walk, was found by Mr. Hart quite frequently on sand dunes.

Diacrisia virginica Fab. April 1.

Two pupae were taken at the edge of bunch-grass, in a hollow log. The moths emerged later, one about April 20, and the other about May 15. The larvae belong to the type of caterpillars known as "woolly bears." The species is generally distributed, and is very destructive in certain localities.

Noctua c-nigrum Linn. April 1.

Taken in fence row, under boards, in the larval state. The noctrid caterpillars are known as cut-worms, from their underground habit of cutting off the stems. They are very characteristic of grassland and cultivated crops. A number of cut-worms occur regularly in the bunch-grass associations; where there these species are the same as those which were present before the cultivation of the region, is a difficult question. The adult noctuids were frequently seen flying about in the bunch-grass, though they are very much more active at night.

Feltia subgothica Haw. April 1, 4.

This is the commonest species of the genus, and the most abundant cutworm of the bunch-grass. Quite generally distributed.

Mamestra meditata Grt. April 1.

Found with other cut-worms in fence row under boards. A common species of economic importance.

Leucania phragmitidicola Gn. April 1, 8.

Under boards with other noctuid larvae and under boards in the Devil's Hole, in bunch-grass. A common and generally distributed species.

Crambus sp. (indeterminable) April 1.

The larva of a crambid moth was taken under a log in a fence row, with other insects.

The Crambids are characteristic grassland species, the larvae living in grass roots. Hart found a number of individuals of _Crambus haytiellus_ Zinck, in the neighborhood of blowouts. The species is described from Hayti, and listed from Texas. Mr. Hart was unable to find other records.

Order DIPTERA

Helobia punctipennis Meig. April 1.

This small Tipulid was very abundant along a roadside east of Havana. On April 1, not long before sundown numbers of small Tipulidae were seen near the hedge flying up and down four or five feet above the ground, in the manner described as breeding swarms. They were in groups of from five to ten.

Chironomid sp. (undetermined) April 8.

The larvae of the Chironomid midges are aquatic, and are very abundant in the river. In the spring and summer, large numbers of the adult flies emerge, and are found at considerable distance from the river. Those which get into the Devil's Hole and other parts of the sand-prairie must add an appreciable food-element to the association, like the Ephemeridae and other non-predaceous forms with aquatic larvae.

Sciara sp. (undertermined) April 1

Found under log in fence row. This genus belongs to the family Mycetophilidae, or fungus-gnats, the larvae of which live in fungi or decaying vegetable matter.

Tabanus constalis? Wied. June 28.

The horse flies, as the Tabanidae are called are swift-flying forms which attack horses and cattle, extracting the blood by means of their powerful beak. On specimen, referred to the above species, was taken in the bunch-grass. Other species were

seen along the road-side. As much of the bunch-grass is pastured, a number of the Tabanidae would be expected in the association.

Anthrax sp. (undetermined) July 19, 29.

Members of this family, the Bombyliidae, are parasitic or partly predatory, according to John B. Smith. Some parasitize lepidopterous larvae; others feed on the egg-pods of grasshoppers, others live in the nests of bees.

Hart records five species of Anthrax from the sand regions. I have seen species of this genus flying about on bare sand or in blowouts, hovering especially over hoof-prints or other impressions in the sand.

Systoechus vulgaris Loew. August.

This species was not taken because of its scarcity early in the season. Mr. Hart found it quite commonly on flowers. This is the small bee-like form which is parasitic on grasshopper egg pods. It is quite generally distributed. A very important member of the bunch-grass association since it is an efficient check upon the numbers of the locusts.

Proctacanthus brevipennis Wied. July 6.

One specimen of this robber-fly was taken at the Devil's Hole, eating a beetle Strigoderma arboricola. The Asilidae are predaceous, swift-flying forms, dominant among the Diptera. They are best developed in the open arid associations of the west and southwest, and are comparatively scarce in the black-soil prairie of Illinois. They are characteristic members of the bunch-grass

association. This species has not been recorded from elsewhere in Illinois.

Proctacanthus rufus Will. July 8, 12.

An extremely large and powerful Asilid, taken eating Tettigidea hieroglyphica on two occasions, once at the Devil's Neck, once at the Devil's Hole. Though characteristically a plains species it ranges east to New Jersey.

Hart took P. milbertii Macq. from August 15 to 20. This is a western species also, and is reported to prey upon the Rocky Mountain locust. The Asilidae in the Illinois region no doubt prey upon its close relative, Melanoplus angustipennis, which is the most abundant bunch-grass insect.

The dates for P. brevipennis range from June 6 to July 6; those for P. rufus, July 8-12 (it was seen later than this), and those for P. Milbertii, August 15-20. A seasonal relation would seem to be clearly indicated.

Syrphus arcuatus Fall. October 7.

The brightly colored syrphid flies feed in the adult stage upon pollen. The lerval food habits vary greatly, but the larva of this species probably lives upon plant-stems, feeding upon plant-lice. The specimens in the Havana series were taken on flowers of aster, along a roadside; they are not restricted to sand regions.

Spalanzania sp. (undetermined). October 6.

A gray Tachinid taken on flowers of Kuhnia, with Pentatomids.

The Tachinids are almost all parasitc, particularly upon caterpillars.

Gonia frontosa Say. April 6

This tachinid was found at the bottom of a hollow between bunch-grass dunes. It had evidently just emerged from the pupa, for the wings and other parts had not hardened. The genus is parasitic upon cutworms, and probably other caterpillars.

Phorbia fusciceps Zett. April 4.

One specimen,from under a log with a large number of other insects, in bunch-grass of advanced stage. Of the family Anthomyidae, the larvae of which include scavengers, parasites, leaf-miners, and root-maggots. This species is a general feeder in roots of common crops, according to Smith. In the natural state it probably feeds on grassroots.

Scatophaga sp. (undetermined). April 1, 8.

Common at the Devil's Hole, flying about in the bunch-grass. The larvae of the Scatophagidae are of various habit, a number occurring in stems of Rumex.

Order HYMENOPTERA

Formica pallide - fulva sub-sp. schaufussi Mayr. April 4, 8.

This large ant is very active. Found commonly under logs in bunch-grass. One nest was found in the roof of a mole burrow. Hister biplagiatus was taken in this nest.

Lasius niger americanus Linn. April 1, 8.

Common in the sandy loam flats, but rare in pure sand or bunch-grass.

Leptothorax sp. (indeterminable). April 8.

A single specimen, taken in a pocket-gopher hill at the Devil's Hole.

Pheidole vinelandica Forel. April 1, 7, 8.

The determination was made by Tanquary and verified by Wheeler. The genus is characteristic of sand habitats. Common under boards in bunch-grass. There are two kinds of workers— major and minor. An elaterid, Cardiophorus cardisce, was taken from one nest. Other nests were taken in the hills of pocket gophers.

Monomorium minimum Buckley. April 1.

A rather common sand species. Taken under log near Devil's Hole.

Sphaerophthalma occidentalis Linn. July 21, 29.

Taken on bare sand of marginal dune sand on blowsand at

the Devil's Hole. A large, rather common species. The mutillidae rest on the bare sand.

Sphaerophthalma ferrugata Fab. June 28, July 19.

Occurs regularly in blowsand and as an interstitial in bunch-grass. The mutillid females run about on the bare sand, the males fly to and fro a few inches from the ground. They are solitary in habit. The species dig burrows in the sand, some storing food for their larvae, 'while others seem to be parsitic or guests in the nests and cells of bees and wasps." (J.B.Smith). This species is rather common and widely distributed, restricted however, to very dry or sandy localities.

Sphaerophthalma chlamydata Mel. July 1, 8, 12, 29 .

Bare sand of marginal dune, blowsand at Devil's Neck and Devil's Hole, in blowouts, and as interstitial species in the bunch-grass. The commonest species of the Illinois River sand region. It has not been taken elsewhere.

Mutilla sp. (indeterminable). October 6.

Two females taken in a blowout, just at the tension line between the basin and the blowsand, at the margin of the Cassia growth. In all probability this is a new species.

Plesia interrupta Say. July 23, October 5.

Taken on flowers of a white aster along roadsides. The females were quite abundant. One male was taken at the border of the Matanzas Lake forest, on Pycnanthemum. Not characteristic of sand.

Hedychrum obsoletum Say. October 7.

One specimen taken on white aster. Hart took it at the Devil's Neck and the Devil's Hole, in August.

Odynerus sp. (undertermined). October 5.

One specimen, from flowers of white aster growing along roadside.

Polistes pallipes St. Farg. October 5, 6.

On aster along roadsides—in the Devil's Hole, according to Hart, on Cassia. In the spring the nests of either Polistes or Vespa were seen in hollow logs along fences. This is one of the true social wasps, which build paper combs. The larvae are fed continually by the adults, which are predaceous. Very common and generally distributed.

Anoplius tropicus Fab. July 23.

One specimen from Pycnanthemum at the margin of the Matanzas Lake forest. Hart found it common in many other parts of the sand regions. He records ten species of Anoplius. The family, Ceropalidae, includes digging species which prey upon insects and spiders. Certain species are said to be guests in the nests of other diggers.

Anoplius sp. (undetermined). July 3.

One specimen from a blowout.

Ammophila extremitata? Cress. October 5.

Taken on aster along a roadside. The single specimen

differs from those in the State Laboratory collection in the color of the base of the fore-wings, and in one or two other respects. Hart took the true extremitata at the Devil's Hole in August.

The family Sphecidae include digging forms which make underground cells, provisioning them with caterpillars, spiders or grasshoppers, which serve as food for the larva.

Ammophila sp. (undescribed, Hart) October 6.

This species, traced down in Melander's key, traces down to A. grossa, which is a large species from Texas. This specimen is quite small, so that it connot be the typical grossa. It may possibly be a geographic variety of the Texas species, changed by isolation in the Illinois sand region.

The specimen was found in an abandoned field, formerly bunch-grass, which was now being stabilized. The dominant growth was Cenchrus. The wasp was observed closing its burrow in the sand. It faced away from the burrow, throwing the sand upon it with the hind legs, then faced about and threw the sand forward, alternating these movements several times.

Prionoryx bifoveolatus Tasch. October 5, 7.

On aster along roadsides, and at the Devil's Hole (Hart) The species probably burrows in sand. It was quite common.

Phionanyx atratus St. Farg. October 7.

Found with the preceding species-one specimen.

Cerceris sp. (undetermined). October 5.

One specimen from aster along roadside. Hart took two species of this genus at the Devil's Hole—*C. fumipennis* Say, and *C. venator* Cress. A member of the Philanthidae, which burrow into the ground and store their cells with beetles or with small digger bees.

Tachytes pepticus? Say. July 19.

One specimen taken flying about the *Cassia* growth in a blowout. A member of the family Larridae, which burrow in sand. Grasshoppers and crickets are used to provision the nests.

Halictus confusus? Smith. October 7.

On aster along roadside. One specimen. Not taken by Hart.

Tachytes sp. (perhaps *obscurus* Cress.) July 3.

Three specimens taken in the basin of a blowout on *Acerates*, the green milkweed. Two were in copula. Hart took *Tachytes obscurus* at the Devil's Hole in August. A characteristic basin species—observed quite frequently on *Acerates*, and in basins about the inner margin of the *Cassia* growth.

A species of *Tachytes* was seen in abundance on the beach sand-plain at Matanzas Lake, July 11.

Augochlora humeralis Patton. June 28, July 8, October 5.

In flowers of wild rose and aster along roadsides; Hart records the species from the Devil's Hole. One of the Halictidae, which are solitary bees. They burrow in the ground.

Agapostemon splendens Lep. October 7.

On aster flowers along roadsides. Quite abundant, both males and females. Hart records the species from the Devil's Neck and the Devil's Hole.

Halictidae, sp. (undetermined). October 7.

On aster along roadsides. Rather large, abdomen red. Not taken by Hart in the sand.

Megachile mendica? Cress. July 11.

Taken on sand-plain of Matanzas Lake beach. One specimen only. Hart took two other species of this genus in the sand region. The family Megachilidae known as the leaf-cutting bees. The cells are constructed of parts of leaves. Solitary bees.

Epeolus cressonii Rob? October 5.

On aster flowers along roadsides. Hart took four other species of Epeolus in the sand regions. A member of the family Nomadidae, which are parasites or guests in the nests of other bees.

Mellisodes sp. (undetermined). October 5.

On aster flowers along roadside. Hart took three other species of the genus in the sand regions. A member of the family Euceridae, which are long-tongued solitary bees, feeding upon honey and pollen.

Melissodes aurigenia Cress. October 5.

On aster flowers with the preceding species.

Bombus virginicus Oliv. October 5.

On flowers of aster particularly. A very common and generally distributed bumble bee. Social in habits. The nests are made in cavities in the ground. The fertilized female hibernates, starting a new colony in early summer. Hart took three other common species in the sand region.

Bombias auricomus Robertson. July 6.

One large specimen, taken from a burrow in bunch-grass. Hart does not record this species from the sand.

AMPHIBIA

Amblystoma tigrinum Green. April 4.

One specimen, taken under a log at the edge of a bunch-grass field, southeast of Havana. Only the fore part of the body was at first to be seen, the rest being sunk into the burrow. The soil was not pure sand—the roots of the grass and the decay of the log having made an approximation to sandy loam. A depression about 100 feet away probably afforded a breeding place.

This large salamander is a prairie species, and is very scarce in the sand region, principally because of the lack of permanent pools.

Bufo lentiginosus americanus Boul. June - July.

Bufo was found but sparingly in the sand-prairie regions, being several times seen along roadsides near the Devil's Hole. It was seen a few times in the black oak forest, from one to two miles from the river. The absence of breeding places is the probable cause of its scarcity. In the mixed forest of the river dunes, and in fact all along the river, the toads are very abundant. They may be seen hopping about, by day; at night they are found on the beach in great numbers.

Americanus is the prairie variety of the toad. Sand-prairie conditions, however, are such to exclude the species.

Frogs are practically absent from the sand-prairie.

REPTILIA

Heterodon nasicus? Bd. & Gir. July 8, 26.

There is some question as to the determination of this blow-snake; unfortunately, the only specimen preserved has been lost. H. Garman reports one specimen from Pekin, which is at the northern end of the sand regions; it ought therefore to be found near Havana. Specimens were taken at the Devil's Hole, the Devil's Neck, the marginal dune north of Havana and a blowsand area southeast of town. Nasicus is the western species of the blow-snake; it is typical of the prairie region. The blow-snake is listed by Hart as H. simus -future collections will settle the question of specific identity. Ecological considerations indicate that it is nasicus.

The blowsnakes are confined to sandy or very dry places. The eggs are laid in summer in the sand. The food consists principally of toads and frogs. The names "blow-snake" and "puff adder" arise from the snake's habit of simulating ferocity by flattening the anterior part of the body and hissing. It also feigns death, lying on its back, reviving, however, long enough to turn over again on its back if placed in any other position.

The blow-snake is a typical predaceous member of the sand-prairie associations.

Cnemidophorus sexlineatus Linn. June 25, 28.

These striped lizards were quite abundant in the bunch-grass in the Devil's Hole and other places. The genus is sub-tropical, all but sexlineatus being restricted to the Sonoran Province. The eggs are laid in a hollow in the sand, and are left to be hatched by

the sun. The food consists of insects and spiders, which are only taken when moving, and other animal food, sometimes the eggs of small ground-nesting birds. The insects most commonly eaten are grasshoppers and beetles. Even active forms like the tiger beetles are captured by the lizards. They are diurnal, solitary, and hide in burrows at night. They are found on the Atlantic coast as far north as Maryland and Delaware, and south and west into Mexico. In Indiana, Illinois they occur in the Lake Michigan sand area, and they are also found at Henry and Ottawa, in dry habitats along the Illinois River.

Cistudo ornata Ag. June 28, July 3,6, October 6.

This is the prairie species of Cistudo, and is much commoner in the sand-prairie than in the other parts of the state. It is very long-lived, hibernating each winter in a deep burrow. It is practically omnivorous. It is known to eat vegetable food; one specimen when first caught had part of the tegmina of a grasshopper adhering to the lower mandible, it ate grasshoppers later from the hand. The movements are usually sluggish. It feigns death when too roughly handled.

The box turtle is found usually in open bunch-grass or blow-sand. Several burrows were found along a fence in sparse growths. It is quite probable that the species is of roving habit. It is a typical sand-prairie species, hardly characteristic of any one of the associations.

Hart has this species listed as Cistudo carolina, which is the forest species of the genus, and which has a distinctly carinated

ridge along the median line of the carapace. The Havana species has not been taken in the woods, and seems to be perfectly at home in the sand-prairie. It has hardly a trace of the dorsal ridge.

AVES.

The bird records for the summer of 1910 are in large part the observations of Mr. F. C. Gates, who has kindly permitted me to use them.

Bird life is scanty on the sand-prairie in comparison with that of the black-soil prairie. There is an abundance of insect food, particularly grasshoppers, and it is thought that severity of nesting conditions is the chief factor in the exclusion of so many birds from the association. Species which nest in hedges and thickets are quite abundant, but the true prairie species, which nest on the ground, are very few.

The A. O. U. checklist, from which the nomenclature was taken, did not cite names of the authors of the various species.

Colinus virginianus virginianus.

The quail or bob-white is of secondary importance in bunchgrass. It feeds in the sand-prairie, much of its food being grasshoppers while these are abundant. Several flocks were seen in spring.

Zenaidura macroura carolinensis.

The mourning dove is of secondary importance in the bunchgrass association. They do not nest in the sand-prairie, and when found are in groups of two or three. They feed upon seeds almost exclusively.

Buteo platypterus, July, April 5.

The broadwinged hawk was often seen soaring above the sand-prairie. It was very frequent in spring. Probably a species to be reckoned with in the sand-prairie associations.

What appeared to be the red-tailed hawks was seen July 25 in the black-oak forest east of Havana, and in several places south of Havana, in April. The marsh hawk was also seen, at a distance from the river, in April.

Coccyzus erythrophthalmus.

The black-billed cuckoo nests in thickets. It is very abundant in the sand-region, and is occasionally seen in bunch-grass, on fences or in shrubbery. At the Devil's Hole they were seen in a small clump of coffee trees. The food consists of insects, notably hairy caterpillars, which other birds avoid.

Tyrannus tryannus.

The kingbird is often seen singly in the bunch-grass, darting from its perch on a fence or bush in pursuit of some insect, It is a thicket species primarily.

Otocoris alpestris praticola.

The prairie horned lark is not listed in Gates' summer records for the sand-prairie. It was quite abundant in spring; it was seen once or twice in sand-prairie, but more often in the cultivated fields. One would expect to find it a typical member of

the bunch-grass association.

Corvus brachyrhynchos brachyrhynchos.

The common crow is seldom seen in the bunch-grass, and then generally singly. A secondary bird species.

Sturnella neglecta?

The western meadowlark is the dominant form in the bunch-grass nesting on the ground in that association. The eastern meadowlark, S. magna, is accidental in the sand-prairie, Mr. Gates assures me, though it is fairly common in the flat areas of sandy loam. Neglecta is a characteristic plains species.

Passer domesticus.

The English sparrow is sometimes found in flock in bunch-grass pasture. Not a typical bunch-grass species.

Pooecetes gramineus gramineus.

One of the dominant species, normally nesting in the bunch-grass. Its food consists largely of grass-hoppers. A western species is found in the same habitat is of the plains region. Quite frequently the vesper sparrow is seen in flock.

Chondestes grammacus grammacus.

Another dominant sparrow of bunch-grass, nesting on the ground. A typical prairie species grasshoppers and other species constitute a considerable proportion of its food. The lark sparrow

is quite frequently found in small flocks.

Spizella pusilla pusilla. April 4,5.

A number of field sparrows were seen in the bunchgrass southeast of Havana. During the first week in April they were common over all the open areas of the sand region.

Cardinalis cardinalis cardinalis.

The redbird is one of the dominant species of thickets in the sand region, in the bunch-grass, however, it is hardly more than an accidental visitor.

Spiza Americana.

Another dominant bunch-grass species, probably nesting on the ground. Seen in flocks or pairs quite frequently. The dickcissel is a characteristic species of the prairie. It diet is partly grasshoppers.

Lanius ludovicianus ludovicianus. July 25.

Rather scarce in the sand-priarie, and perhaps more typical of the cultivated fields than of the bunch-grass. Seen in the Devil's Hole on fences. The shrike eats numbers of locusts and other insects.

Mimus polyglottos polyglottos.

The mockingbird, though characteristic of thickets, is more often seen in the bunch-grass than is the brown thrasher. Much of the

food consists of insects, largely grasshoppers.

Toxostoma rufum.

Though primarily a bird of thickets, the brown thresher is often seen in the bunch-grass on fences. A grasshopper feeder to some extent.

Sialia sialis sialis. July 15.

Found often in high perches in open places. Often seen on telegraph wires near bunch-grass. Not a sand-prairie species. Commonly seen in spring.

MAMMALIA

Peromyscus maniculatus bairdii Hoy and Kennicott. July 5, April 4.

The white-footed prairie mouse is very common in the bunch-grass, being the most abundant rodent of the sand-prairie. The burrows have usually two or three openings, and are seen throughout the bunch-grass, though in pastures the holes are more frequent along the fences. The food is principally vegetable. Almost all rodents eat animal food on occasion, and no doubt this species eats a number of insects. The prairie white-foot is very prolific, there being three broods each year, with from four to nine in a litter. The species stores up food, remaining active all winter.

Peromyscus is a very important animal of the bunch-grass. The nocturnal carnivores and owls, and probably the snakes of the region, feed principally on this species. Among the larger animals it occupies a similar position to that of Melanoplus angustipennis among the insects. It is a dominant form. Undoubtedly Peromyscus bairdii is not the only small rodent of the sand-prairie. In thicket and near forest borders, the white footed wood mouse P. leucopus noveboracensis will probably be found. The prairie meadow-mouse, Microtus austerus, should be present in the open fields. One of the spermophiles, Citellus franklini or C. tridecemlineatus is no doubt present. The work on the mammals was quite fragmentary.

Geomys bursarius Shaw. June 25, 28, October 7, 8,

The burrows of pocket gophers, with the characteristic mounds

of sand, are quite common in the bunch-grass, and in several places were seen in blowsand, with sparse vegetation. Mr. Wood has taken the species at the Devil's Neck. Figure 22, p.179, shows their mounds.

The species is vegetarian, is active during the winter, storing up large quantities of roots and other vegetable matter. It is solitary. It is strictly a subterranean species, coming to the surface only in the breeding season.

Illinois is near the eastern part of the range of the pocket gopher. Coming through the Kankakee sand region in eastern Indiana, I saw from the train mounds which could hardly have been other than those of Geomys. The eastern limit of the range should be looked for in a sandy region.

The pocket gophers begin active tunneling very early in the spring. During the greater part of the April visit there were heavy rains and as soon as these were over many fresh mounds were observed.

Silvilagus floridanus mearnsi Allen. June 28, October 6, April 4.

The cottontail, our commonest rabbit, is quite abundant in the sand region. They are sometimes true prairie forms, but more often their dens are in forest borders or thickets. They are very prolific. Since their natural enemies, the larger carnivores, are now almost extinct, their numbers would now be overwhelming were it not for the number that are shot each year by sportsmen. The food is almost exclusively vegetable.

The rabbit is one of the important plantfeeding species of the sand-prairie. They are quite frequently seen in the blowsand. but are more prevalent in bunch-grass.

Mephitis mesomelas avia Bangs. April 4, 5.

This subspecies of skunk is recorded by Wood from San Jose, Mason County. None of the animals were seen, but large burrows and suspicious odors encountered together on two occasions corroborated the statement of one of the farmers residing near the Devil's Hole, to the effect that skunks are common in the sand-prairie. The dens were seen, one northeast of the Devil's Hole, and the other south of Havana. The skunk is carnivorous, eating insects, frogs, mice and other small mammals, bird's eggs, and poultry. It is sluggish and not very shy.

Though the skunk causes considerable change in the animal life of an association wherever it goes, it is never abundant, and thus probably is of little influence upon the association in the long run.

Several other carnivorous mammals no doubt exist in the sand region, especially the weasel, Putorius noveboracensis Emmons.

Scalopus aquaticus machrinus Rafinesque. July 5.

One specimen,, from a nontypical part of the Devil's Hole, where the blue grass had invaded, forming a sod. The common mole is also quite freguent in the bunch-grass, where its tunnels are often seen. On one or two occasions the burrows were seen in

almost pure sand.

Several other insect-eating mammals are likely to be present in the sand prairie also. Of these, *Blarina brevicauda* Say, and one or two bats are almost certain to be found.

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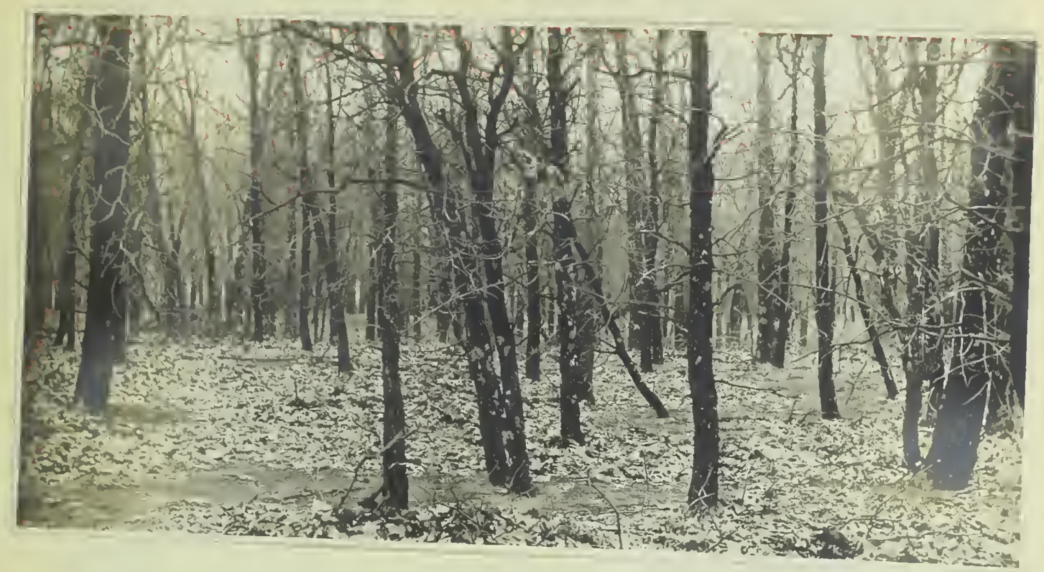

Figure 12.

Typical black-jack oak growth southeast of Havana.

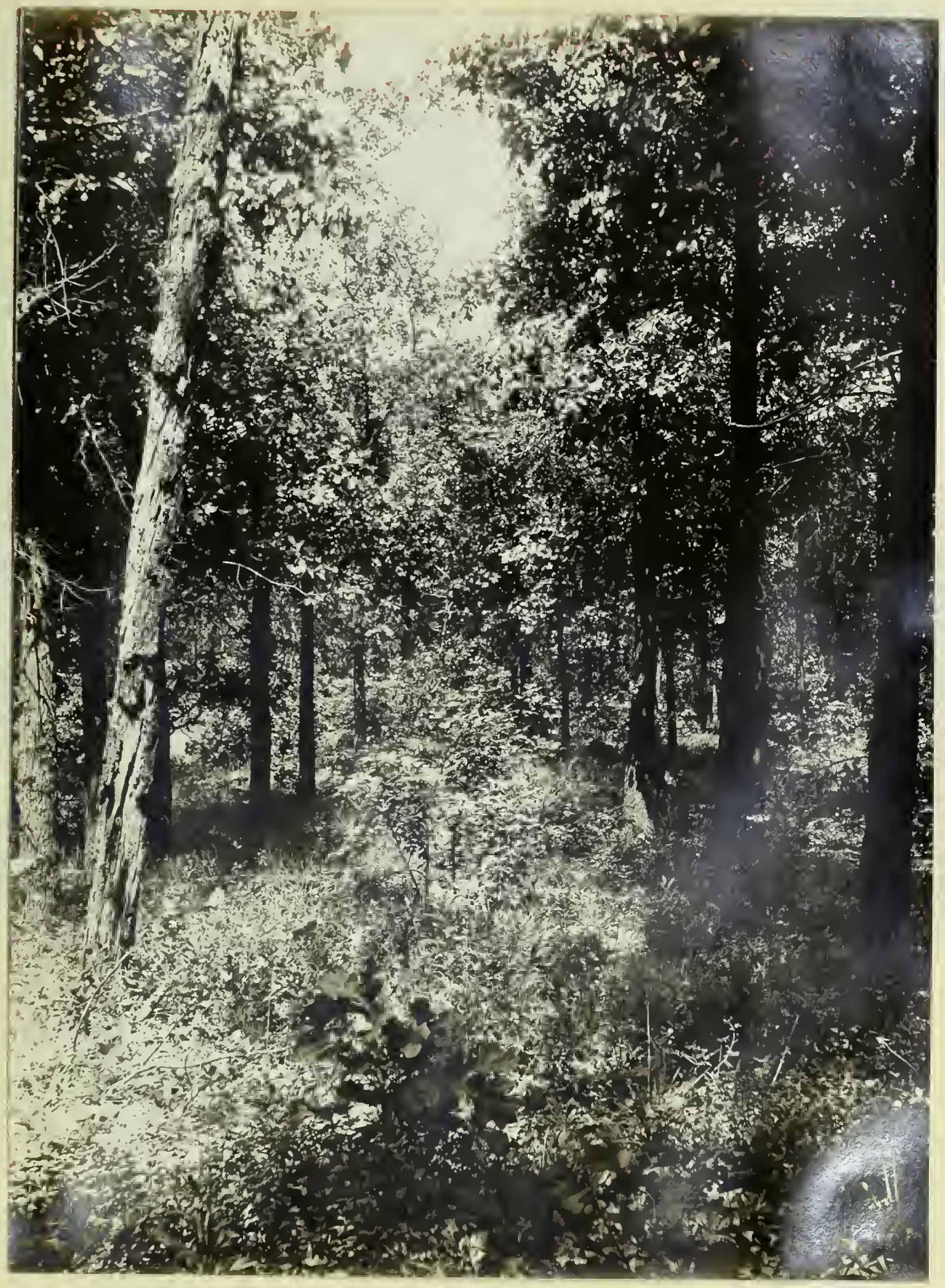

Figure 13.

Interior of a young stage of mixed forest east of the Devil's Hole. The young oak in the foreground is the black-jack (*Quercus marilandica*).

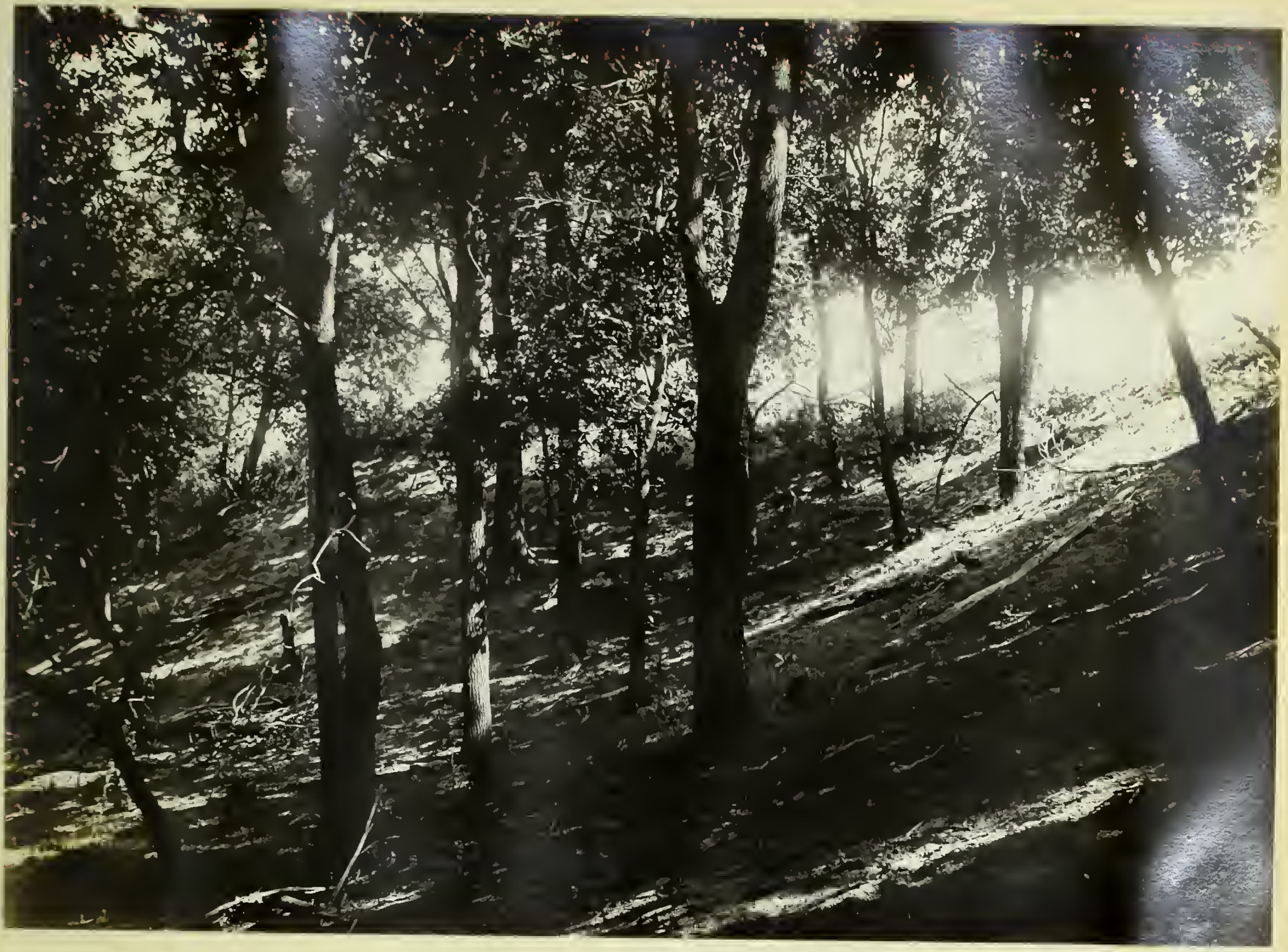

Figure 14.

Forested lee slope of a large sand dune at the Devil's Hole. The trees are walnut, hackberry, and coffee-tree.

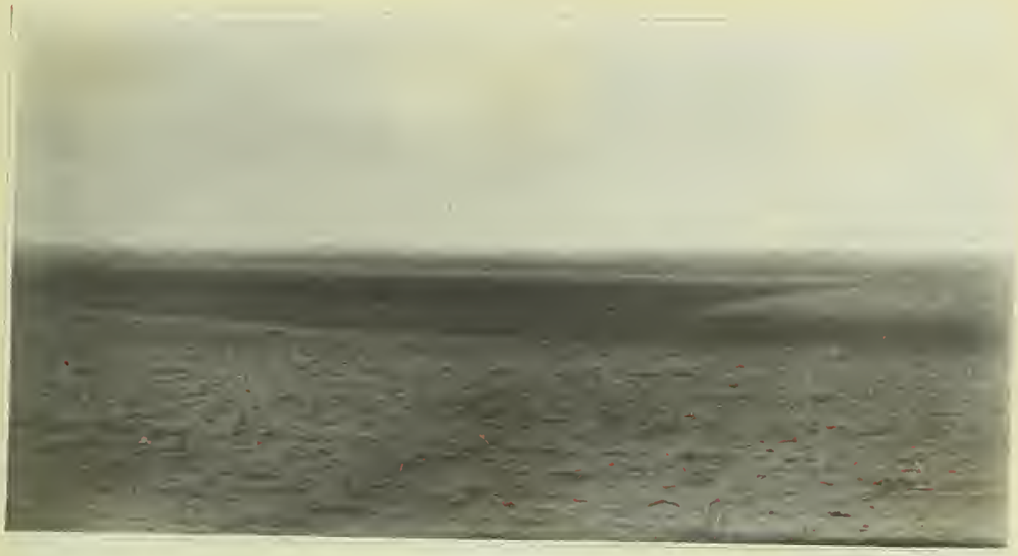

Figure 15.

The Crane Creek flat, from a dune southeast of Poplar City.

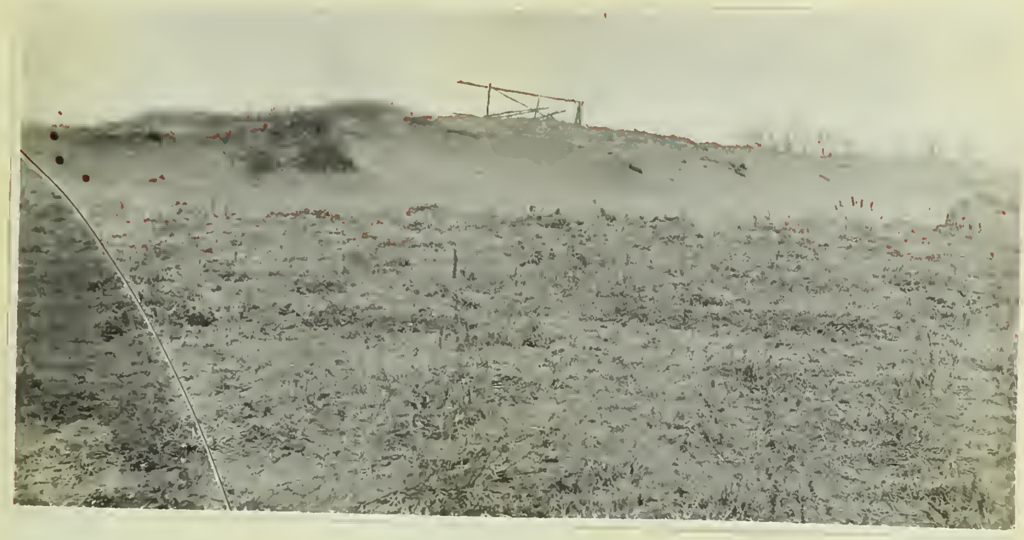

Figure 16.

Summit of "Watch-Tower Hill" north of the Devil's Neck. The tower has blown down in the last few months. Dunes of Rhus canadensis illinoensis to the left.

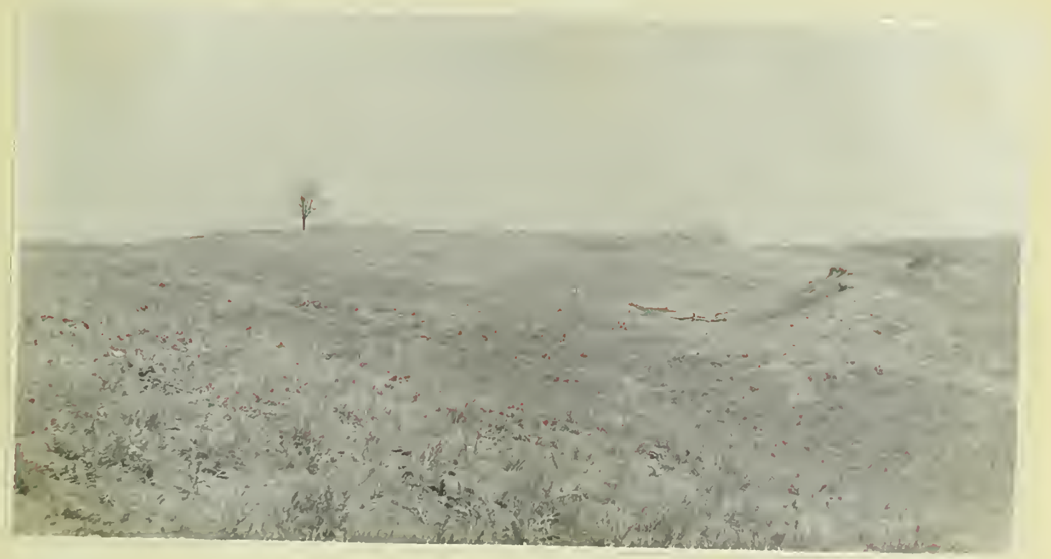

Figure 17.

The large bare sand area at the Devil's Hole. A new blowout at the right.

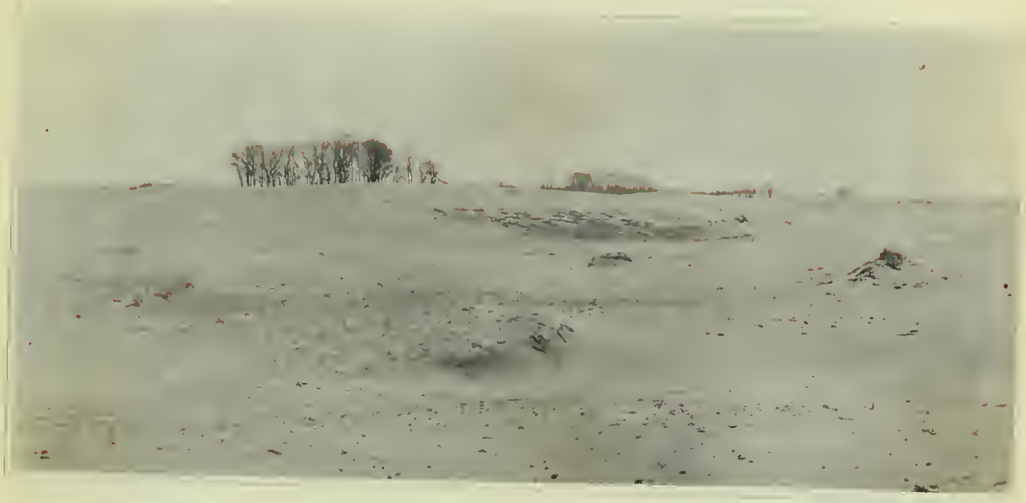

Figure 18.

The sandy waste known as the Devil's Neck, 3 miles north of Topeka. Most of its area is bare sand. The erect Populus deltoides can be seen in the right back-ground.

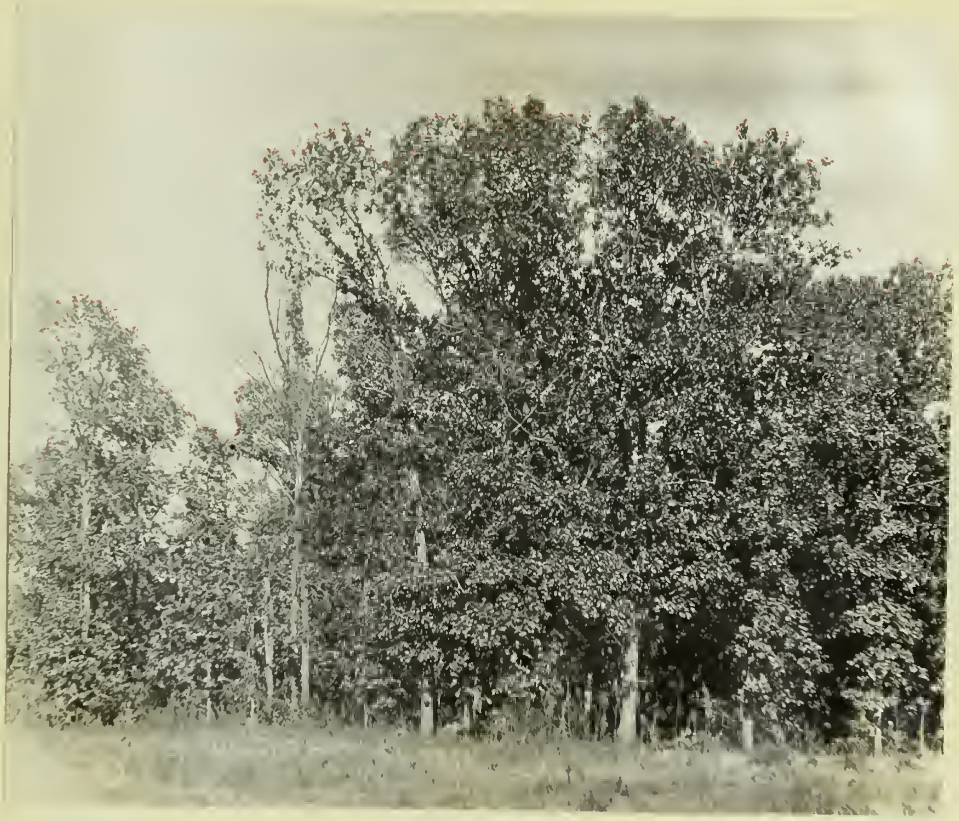

Figure 19.

Exterior of the black-oak forest east of the Devil's Hole.

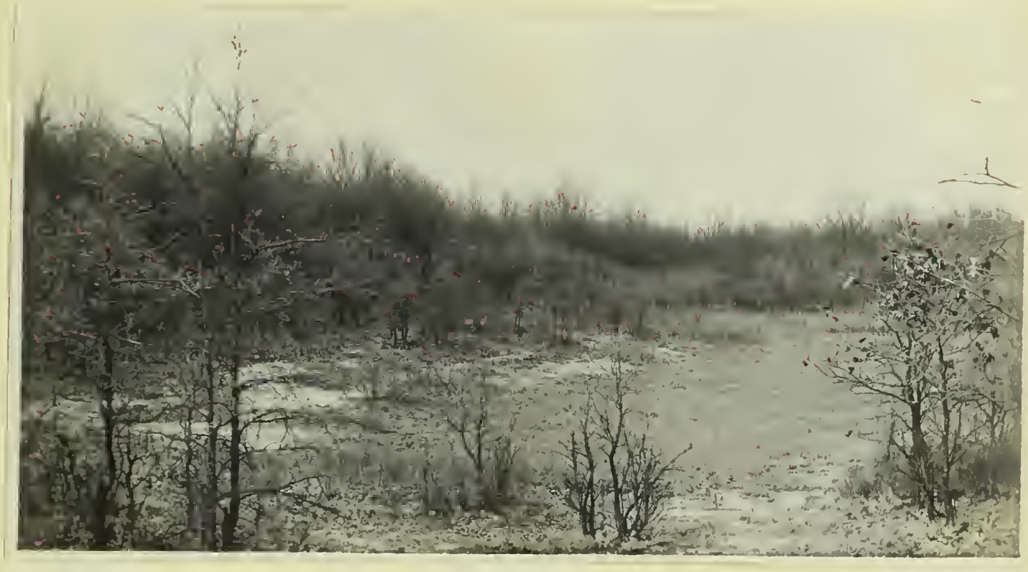

Figure 20.

A bunch-grass hollow in the black-jack dune complex southeast of Havana.

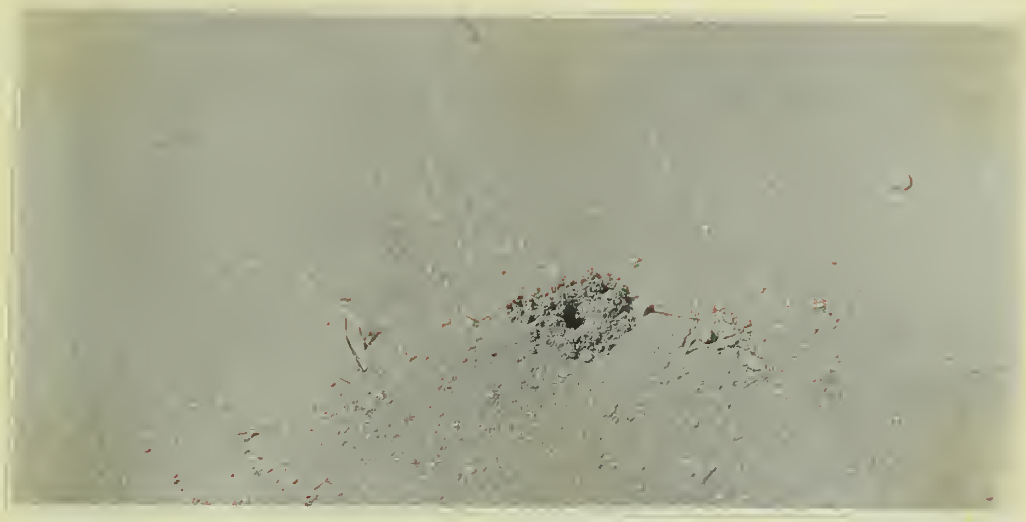

Figure 21.

Burrow of Lycosid (ground spider) in a large blowout.

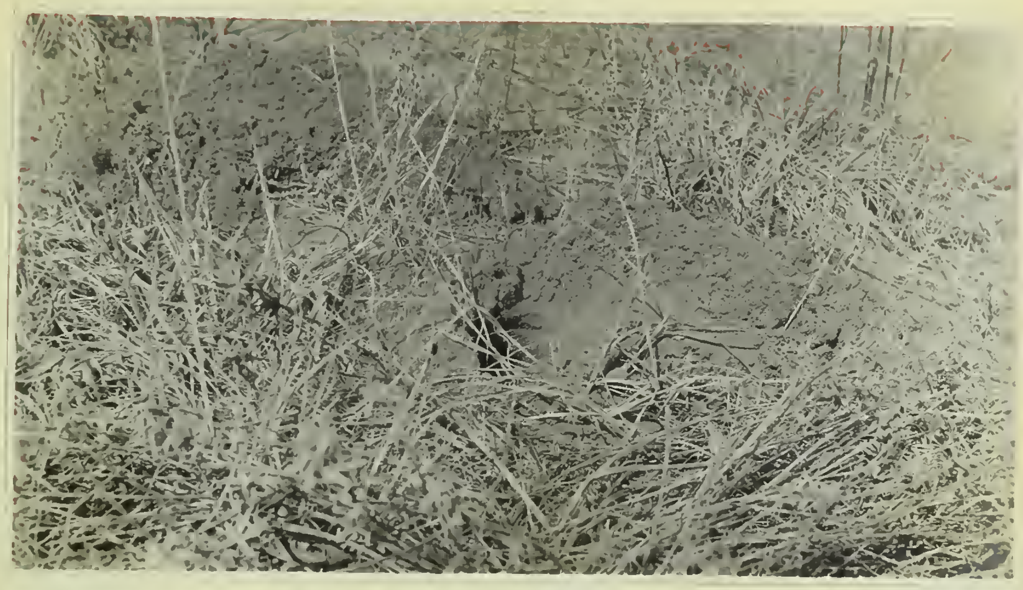

Figure 22.

Mounds of Pocket Gopher. The opening was made to show the direction from which the sand had been pushed out.

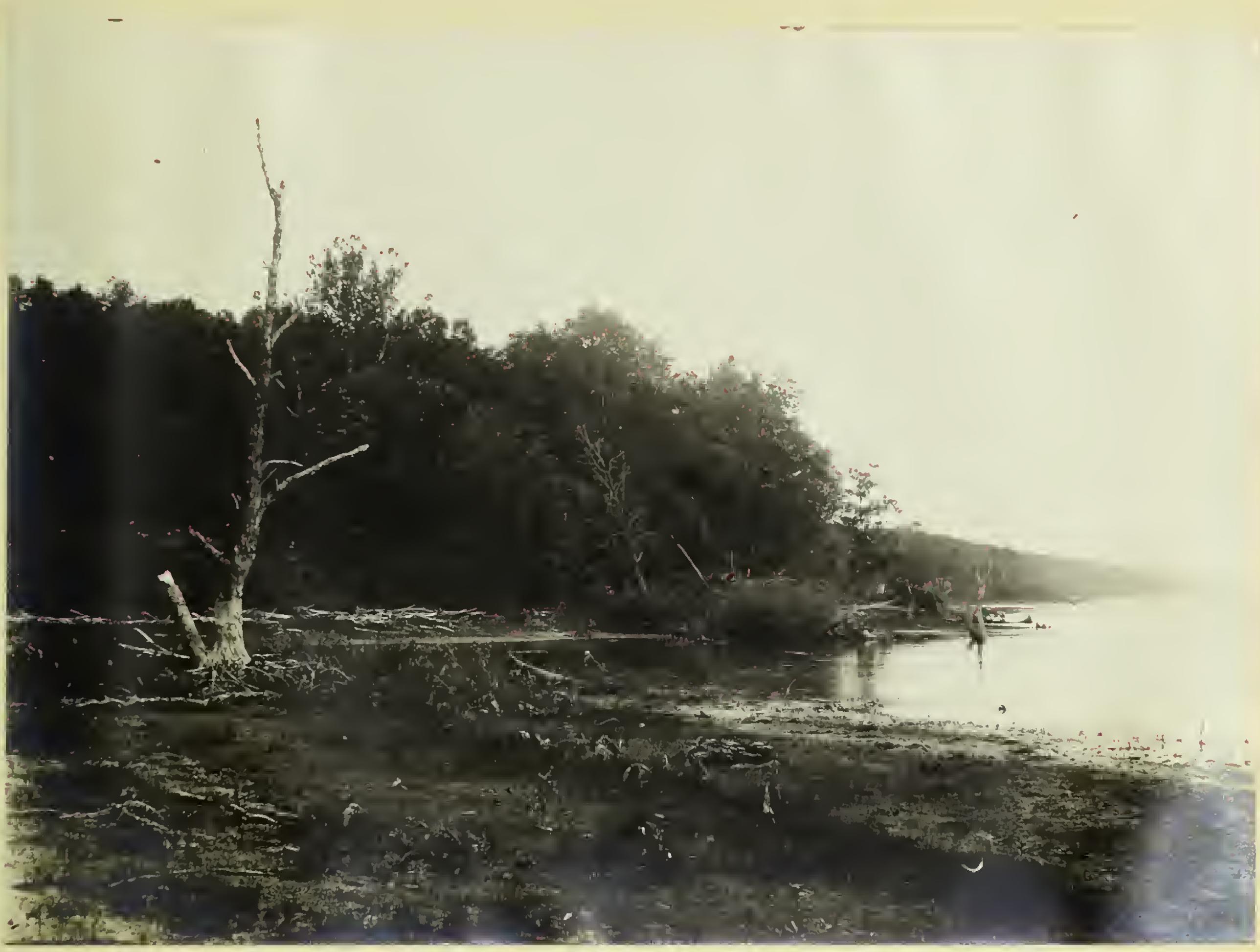

Figure 23.

The shore of Matanzas Lake. Just inward from the beach at this point, and northward along the foot of the bluff, is a bog association, in which a number of northern bog plants are found.

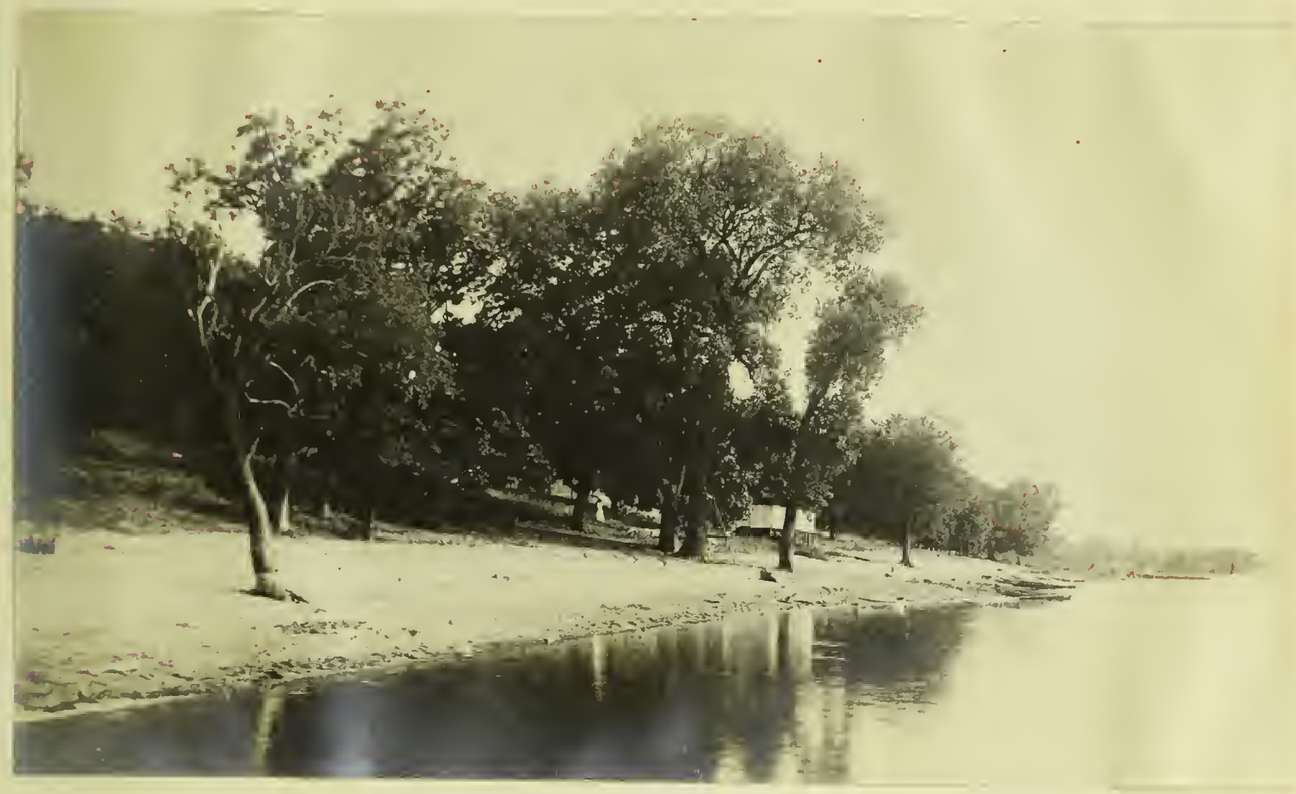

Figure 24.

The Quiver Lake beach. The lake and the river at this point are confluent. The marginal dune. with a mixed forest growth, rises in a steep slope from the beach.

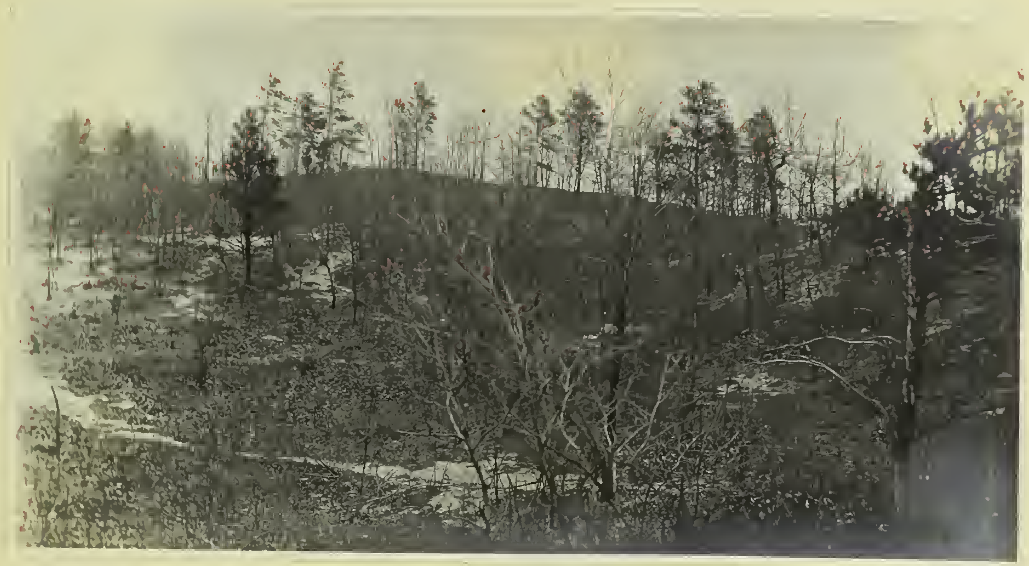

Figure 2 .

A dune complex at Miller's, Indiana, in the sand regions of Lake Michigan. A new geographic element is introduced - the northern coniferous forest.

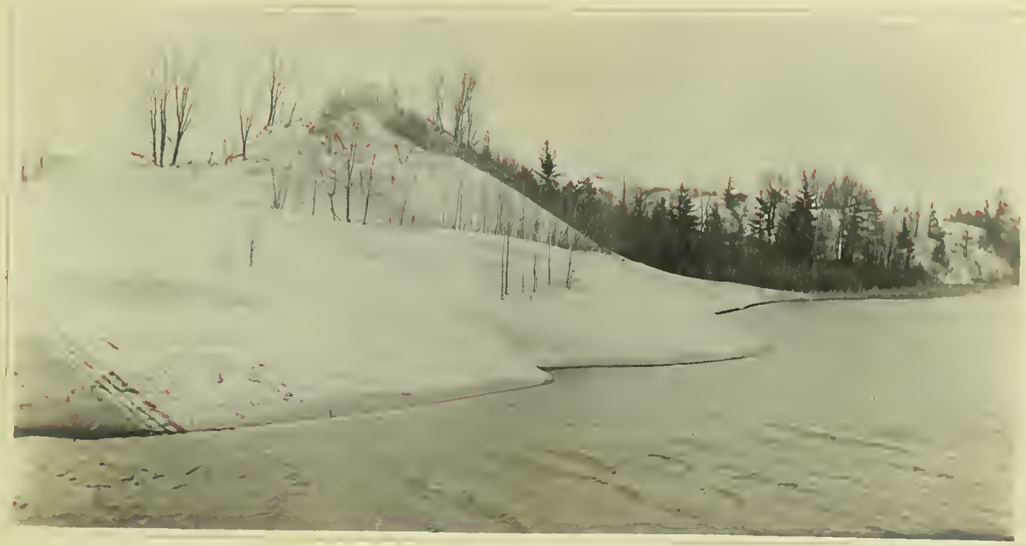

Figure 26.

A sand dune in the Lake Michigan Region, at Millers, Indiana. The northern conifers may be seen at the right. At the crest of the dune a cloud of sand is being blown into the air. The exposure was made on a very windy day. The sand of this region is finer than that of the river dunes in central Illinois.

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